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Effects of Heated Discharges from Gulf Power on the Temperature Regime and Biota of the Lower Escambia River

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EFFECTS OF HEATED DISCHARGES FROM GULF POWER ON THE TEMPERATURE REGIME AND BIOTA OF THE LOWER ESCAMBIA RIVER

January 1973

Environmental Protection Agency
Surveillance and Analysis Division
Athens, Georgia

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The report presents temperature studies of the Lower Escambia River. Studies of the invertebrate fauna and flora and in situ fish bioassay studies were conducted during September and October 1972. On July 20, 1972, discharges from the Gulf Power steam electric facility flowing into the Escambia River increased surface water temperature to 93F, 100 yards downstream from the point of discharge (POD). This represented an 11F increase over ambient temperatures recorded upstream from the point of discharge.

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SUMMARY

During July 1972, personnel from EPA's Surveillance and Analysis Division laboratory in Athens, Georgia, conducted temperature studies of the Lower Escambia River. Studies of the invertebrate fauna and flora and *in situ* fish bioassay studies were conducted during September and October 1972.

On July 20, 1972, discharges from the Gulf Power steam electric facility flowing into the Escambia River at approximate River Mile 2.6 increased surface water temperature to 93°F, 100 yards downstream from the point of discharge (POD). This represented an 11°F increase over ambient temperatures recorded upstream from the point of discharge.

On September 29, 1972, surface water temperature of 101.8°F, 17.2° above ambient, were recorded near the west shoreline of the Escambia River 3 yards downstream from the Gulf Power POD.

During low tide on July 20, 1972, water temperatures 6°F to 11°F above ambient were recorded in the upper 4 feet of water at a transect station one-half mile downstream from the Gulf Power POD.

The Monsanto outfall increased near-surface water temperatures 2°F in a very localized area of the river and the effects of this increase are considered to be insignificant. Therefore, no biological studies were conducted in the vicinity of the Monsanto outfall.

On September 20, 1972, at sampling stations downstream from the Gulf Power POD, there were significant reductions in the diversity of the invertebrate fauna and the flora as compared with diversity of fauna and flora at stations upstream from the Gulf Power POD. Invertebrate

organisms known to be intolerant of heated water were entirely absent from samples collected 100 yards downstream from the Gulf Power POD. The periphytic flora at this same sampling area was dominated by heat-resistant blue-green algae of the genus Oscillatoria.

At the Gulf Power POD and for distances up to 1 mile downstream, the heated discharge from Gulf Power increased Escambia River water temperatures to a level which was lethal to fish life.

It is concluded that discharges from the Gulf Power steam electric facility are causing damage to the aquatic flora and fauna of the Escambia River and therefore are subject to abatement under state and federal standards for heated water discharges into the public waters of the state of Florida.

INTRODUCTION

The third session of the Federal-State enforcement conference on the pollution of Escambia River and Bay, held January 24-25, 1972, recommended (Recommendation No. 9) that the biological effects of heated discharges from Monsanto Chemical Company and Gulf Power Company be determined.

The Florida standards for temperature state that "heated water discharges existing on July 1, 1972, shall not increase the temperature of the receiving body of water (RBW) so as to cause damage or harm to the aquatic life or vegetation therein or to interfere with beneficial uses assigned to the RBW." The Escambia River has been assigned to Class III - Recreation, Propagation and Management of Fish and Wildlife.

To carry out the recommendations of the conferees and determine if standards were being violated, temperature and biological studies were conducted by personnel from EPA's Surveillance and Analysis Division laboratory in Athens, Georgia, during the summer of 1972.

RESULTS

Temperature

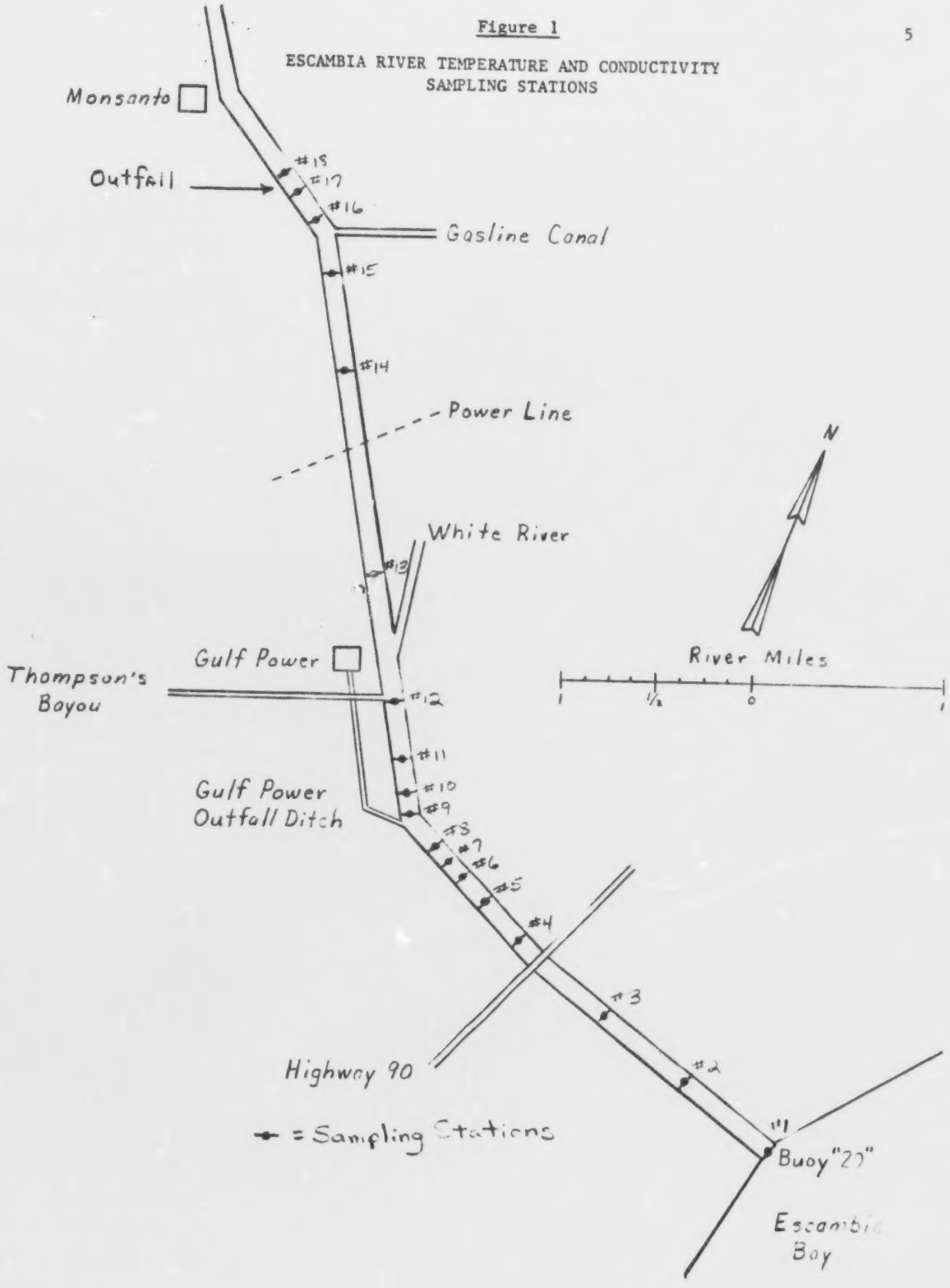
On July 20, 1972, vertical and horizontal water temperature and conductivity profiles were determined during high and low tides at 18 stations on the Escambia River. Stations were located from 100 yards upstream of the Monsanto outfall to the mouth of the river at channel marker #20 (Table 1 and Figure 1).

During high tide, the surface temperature of the river was increased from an ambient temperature of 82°F to a maximum of 93°F at a point (Station 8) 100 yards downstream from the Gulf Power outfall (Figures 10 and 38). The 93°F temperature water extended across the river in the surface 1 foot of water. At a depth of 5 feet, the temperature had decreased to 85°F. This heated plume of surface water was apparent 1,300 yards downstream from Gulf Power at Station 4, where it was well-mixed vertically, with a range in temperature from 85°F near the bottom to a maximum of 86.5°F at the surface (Figure 6). Temperatures 5° to 5.5°F above ambient extended to depths of 7 feet at Station 5 (800 yards downstream from Gulf Power). At Station 3, approximately 1.25 miles downstream from the Gulf Power outfall, the heated water was on the bottom of the river (Figure 5). At this point (Station 3) the temperature of the bottom water was 2.5°F warmer than the bay water on the bottom at channel marker #20.

During low tide, the ambient surface temperature of the river was increased 12°F by the Gulf Power outfall (Figures 28 through 30 and 37). This heated water was spread across the river in the upper 1 foot, and

Figure 1

ESCAMBIA RIVER TEMPERATURE AND CONDUCTIVITY
SAMPLING STATIONS



the temperature had decreased to 87°F (6°F above ambient) at a depth of 4 feet. At Station 5, approximately 0.5 miles downstream from the Gulf Power outfall, water temperature ranged from 87° to 92°F (6° to 11°F above ambient) in the upper 4 feet of the river (Figure 25).

As shown by the conductivity data (Tables 2 and 3), saline water extends upstream along the bottom of the Escambia River to the vicinity of Monsanto Chemical Company's outfall (approximately 6 miles upstream from the river mouth). On high tide, water conductivity exceeded 10,000 µmhos upstream as far as Station 14 (5 miles upstream from the river mouth); while on low tide, conductivity greater than 10,000 µmhos extended upstream to Station 4 (less than 2 miles upstream from the river mouth).

From the Gulf Power outfall upstream to Station 13 (approximately 1.5 miles), the more saline bottom water was 2° to 3°F warmer than surface waters. This temperature inversion was particularly apparent on high tide (Figures 12 to 15). Based on the high tide temperature differential between bottom water influenced by the Gulf Power discharge (Figure 5) and the temperature of bottom waters at the mouth of the river (Figure 3), the higher temperature of this saline underflow was predominantly a result of the Gulf Power heated discharge.

The Monsanto heated outfall increased surface water temperatures approximately 2°F. On high tide water temperature at the station upstream from the Monsanto outfall (Station 18) appeared to be influenced by heated water from the outfall (Figure 19) and some evidence of the heated water persisted to Station 14, approximately 1 mile downstream from the Monsanto outfall.

On low tide, the heated water was evident at Station 16, 400 yards downstream from the outfall. No samples were collected at Stations 14 and 15 on low tide and evidence of the heated water was absent in the section of river from Stations 10 to 13 (Figures 30-33).

Macroinvertebrates

On September 27, 1972, the macroinvertebrate community was sampled quantitatively a d qualitatively at two stations located adjacent to the west bank of the Escambia River at points 100 yards upstream and 100 yards downstream from the mouth of Gulf Power's effluent ditch. Substrate characteristics at the two sampling sites were quite similar (Table 4).

Three replicate quantitative samples were collected at each location with a Ponar grab. Qualitative samples were collected by screening and visual examination of materials from rocks, detritus and vegetation. Two experienced aquatic biologists spent 1 hour collecting the qualitative samples at each sampling site.

There were no detectable differences in numbers of taxa or numbers of individuals of macroinvertebrates collected from sediments with the Ponar grab sampler at the stations upstream and downstream from the Gulf Power effluent ditch (Table 5).

Exhaustive qualitative sampling of a variety of substrates revealed 23 genera and species of macroinvertebrates upstream from the effluent ditch as compared with 15 genera and species downstream from the ditch. Although quite abundant upstream from the effluent ditch, no amphipod crustaceans or bivalve molluscs were found found living in the heated water downstream from the ditch (Table 6).

Taxa which were abundant upstream from Gulf Power but absent at the downstream station included amphipods of the genera Gammarus, Melita, and Corophium and molluscs of the genera Mytilus and Mulinia.

Periphyton

On September 27, 1972, samples of periphytic growths along the west shore of the Escambia River were collected at stations upstream and downstream from the Gulf Power outfall ditch and at one station in the outfall ditch (Table 7). The samples were collected from natural substrates including cattails, dead tree stumps and limbs of fallen trees lodged along the shoreline of the river.

At the station upstream from the Gulf Power ditch, there was a wide representation of algal forms dominated by filamentous green algae and pennate diatoms (Table 7). At stations in and downstream from the effluent ditch, there was a reduction in the number of algal forms found and the flora was dominated by filamentous blue-greens primarily of the genus Oscillatoria. This dominance of blue-green algae extended at least 250 yards downstream from the outfall ditch where river water temperatures were elevated 11.5°F over ambient temperatures upstream from the outfall. Of the various forms of algae shown in Table 7, the blue-greens are most tolerant to elevated temperatures, greens intermediate, and diatoms least tolerant (1). Blue-green algae, particularly Oscillatoria, have been considered indicators of extreme thermal pollution (2, 3).

Fish

In situ bioassays were conducted on October 3 through 10, 1972, in Escambia River at Pensacola, Florida. The objective of these bioassays

was to determine if heated water discharged into the Escambia River by Gulf Power was lethal to fish.

The test organisms, a mixture of bluegill sunfish (Lepomis macrochirus, Raf.) and redear sunfish (Lepomis microlophus, Gunther), were obtained on September 29, 1972, at the Florida state fish hatchery at Holt, Florida. The fish were between 1 and 1 1/2 inches long and consisted of approximately 95 percent bluegills and 5 percent redear. They were transported via truck in aerated containers from the hatchery to the Escambia River.

Six stations were selected for temperature and salinity measurements (Figure 2). Of these six, three stations were selected to evaluate the effect of heated water on sunfish survival.

Station I - Escambia River, 150 yards downstream from U. S. 90 bridge approximately 2 yards from west bank. Depth of water was approximately 4 feet.

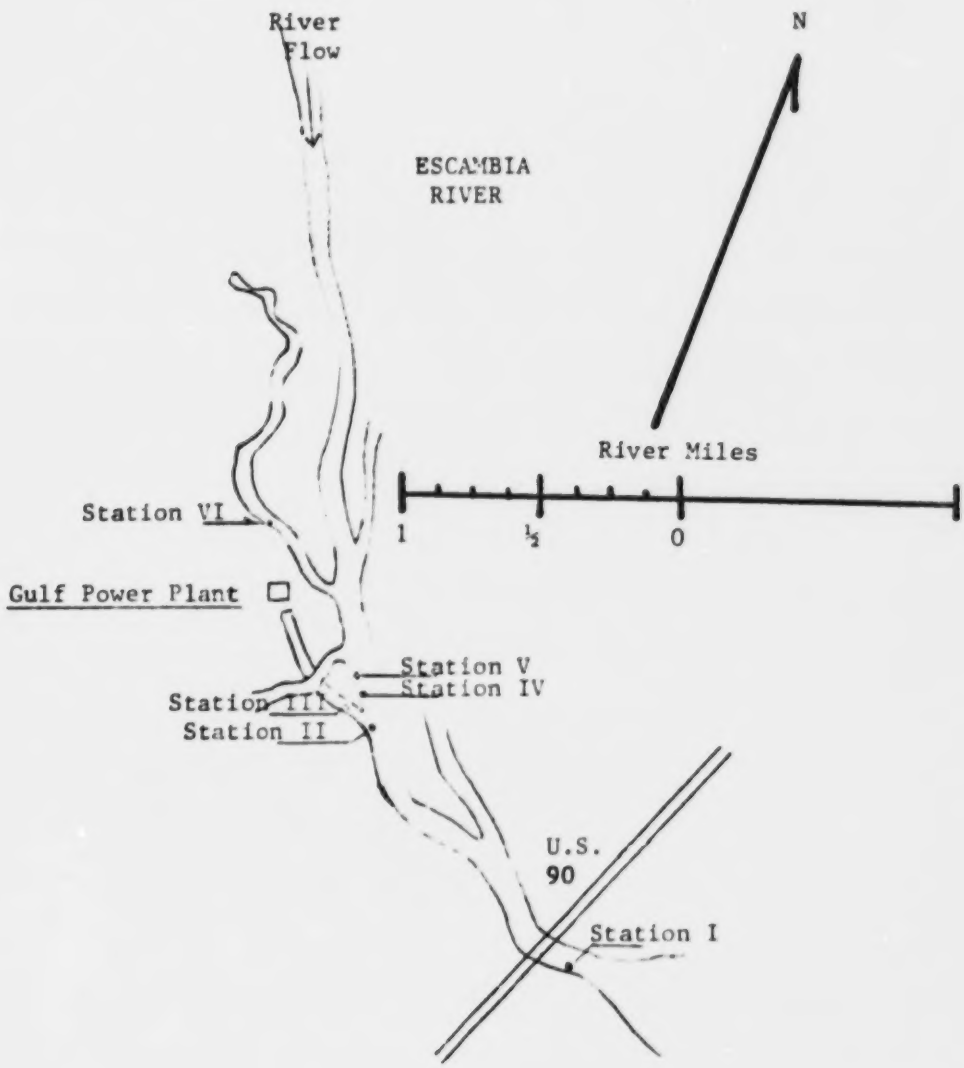
Station II - Escambia River, 3 yards downstream from confluence with Gulf Power discharge ditch where right bank of ditch meets west bank of Escambia River. Depth of water was approximately 9 feet.

Station III - Gulf Power discharge ditch between 50 and 100 yards upstream from confluence with Escambia River and centered between right and left bank of ditch. Depth of water was approximately 9 feet.

Station IV - Escambia River, 150 yards upstream from confluence with Gulf Power discharge ditch, 3 yards from west bank. Depth of water was approximately 9 feet. This was the control station.

Figure 2

LOCATIONS



Station V - Escambia River, 350 yards upstream from confluence with Gulf Power discharge ditch, approximately 3 yards from west bank. Depth of water was approximately 4 feet.

Station VI - Gulf Power intake channel, approximately 25 yards out from trash racks. Depth of water was approximately 9 feet.

Water temperatures were measured with a thermister at 1 foot, 4 feet, and on the bottom (9 feet) at selected stations. These measurements were recorded along with salinity data which were also taken from the same water depths. Salinities were determined with a refractometer.

Sunfish from the Holt hatchery were taken to Station V on September 29, 1972, and evenly distributed in seven cages of 1/8-inch square mesh hardware cloth. These cages were approximately 1 to 2 cubic feet in volume. All but two cages were wrapped on four sides with cloth. Bricks were placed inside the cages for added protection against the current. With these two protective items, the fish were able to maintain their swimming position in the cages. All cages were held at Station V at a water depth of 4 feet for 72 hours to acclimate the fish to Escambia River water quality, temperature, and salinity. On October 2, after 72 hours, fish were redistributed so as to have a total of 10 healthy fish in each cage. Cages were replaced at Station V for an additional 24 hours. With the exception of the shock experiments discussed below, these caged and acclimated fish were used for all *in situ* studies.

On September 27 and 29, 1972, water temperatures at stations in the Gulf Power effluent canal and immediately downstream (Stations II and III) were approximately 17°F higher than river water at Stations IV

and V, upstream from the effluent canal (Table 8). A cold front passed through the Pensacola area during the night and early morning hours of September 29 and 30 with concomitant rain and cool air temperatures. Subsequent to passage of the cold front, there was a considerable reduction of water temperatures in the effluent canal and in the Escambia River (Table 8).

In the reach of the Escambia River studied, there was a narrow wedge of more dense saline water from Pensacola Bay overlain by freshwater of lower density moving down the Escambia River (Table 9).

On October 3, 30 fish which had been acclimated at Station V for 96 hours were divided equally among three cages. Single cages containing 10 fish each were then placed at Station II and at control Station IV by floating the cages downstream with the current. Each cage was anchored and floats attached to keep the cage 4 feet below water surface. Fish for the third cage were transported in a bucket from Station V to Station I, placed in a cage, and anchored in 4 feet of water. At the control station (Number IV), upstream from the Gulf Power effluent ditch, no mortality had occurred after 96 hours (Table 10). At Station II immediately downstream from the effluent ditch 80 percent of the fish were dead at the end of 48 hours, after which the cage at Station II disappeared. At that time, the temperature was 13.2°F higher at Station II than at Station IV and salinity was 5 ppt greater. At the station 150 yards downstream from Highway 90 bridge (Station I), a mortality of 30 percent had occurred at the end of 96 hours. Temperature at Station I after 48 hours was 0.9°F higher than at Station IV and salinity was 11 ppt greater. The increase in salinity at Stations I

and II probably had an influence on mortality of experimental fish. Even though the greater mortality of fish at Station II may have been influenced by salinity, the higher temperature was a greater factor in the mortality of those fish.

Experiments were conducted in the field and at the EPA's Athens, Georgia, laboratory to determine the effects of sudden exposure to elevated temperatures such as might occur when adult fish, fingerlings, or fry move downstream in the Escambia River past the mouth of the effluent canal.

On September 29, 10 unacclimated fish were placed in a cage which was 1 foot below the water surface in the Escambia River 50 yards upstream from the Gulf Power discharge ditch. The cage was floated with the current downstream from 84.6°F water into 101.8°F water being discharged by Gulf Power. All ten fish died after 2 minutes' exposure to the elevated temperatures. Similar results were obtained in four laboratory experiments when fish acclimated at 82°F were placed into water having temperatures of 95.0, 96.8, 98.6, and 99.5°F. Reaction to the thermal shock in these field and laboratory experiments included rapid, thrashing movements, loss of equilibrium, flared operculars, gaping mouths and death.

DISCUSSION

Heat added to an aquatic ecosystem may affect the biota in a number of ways including direct mortality from thermal shock, reproductive suppression, prevention of normal migratory movements, reduction in diversity, and stability of the communities of organisms inhabiting the system.

Numerous workers have shown that for freshwater organisms, such as those indigenous to the lower Escambia River, water temperature should not exceed 30-32°C (86-89.6°F) for long periods of time (Coutant, 1962; Cairns, 1956; Alabaster, 1963). Ambient summer temperatures of the Escambia River seldom exceed 29°C (84.2°F).

The Gulf Power facility increased July surface water temperatures of the Escambia River to 93°F (33.9°C) at a transect approximately 100 yards downstream from the Gulf Power outfall ditch. The 93°F represented an increase of 11°F over ambient river temperatures found upstream from the outfall ditch. During low tide water temperatures from 87-92°F (6° to 11°F above ambient) were detected in the upper 4 feet of water one-half mile downstream from the Gulf Power outfall ditch and these elevated temperatures extended across the full width of the river. During late September river water temperatures 17°F higher than ambient were detected 3 yards downstream from the Gulf Power discharge.

During September 1972, in the heated water downstream from the Gulf Power outfall, there was a reduction in diversity of invertebrate taxa as compared with diversity in samples collected at ambient river temperatures upstream from the outfall. Using the method of Beck (4),

Mr. Bill Young, biologist for the Florida Department of Pollution Control, found a reduction during April and May 1970 in the biotic index downstream from the Gulf Power outfall (5).

Amphipod crustaceans and bivalve molluscs of the same genera and species, which were absent downstream from the Gulf Power outfall, have been shown to be intolerant of heated waters (3, 6, 7, 8). Mihursky and Kennedy (8) reported 50 percent mortality of the scud Gammarus mucronatus at a water temperature of 31.5°C (88.7°F). This scud was not collected in samples downstream from Gulf Power but was abundant at ambient river temperatures upstream from the Gulf Power outfall.

The periphytic community downstream from the Gulf Power outfall was dominated by blue-green algae of the genus Oscillatoria, a form reported to be abundant under conditions of extreme thermal pollution (2, 3).

Water temperatures at the Gulf Power point of discharge on September 29, 1972, were lethal to fish life. Ten sunfish acclimated to ambient river water temperature survived less than 2 minutes after being placed in the heated river water near the Gulf Power effluent ditch.

Although during the period of in situ bioassay studies water temperatures decreased considerably after passage of rain and a cold front, there was significant mortality of caged fish placed at depths of 4 feet in the Escambia River immediately downstream (< 3 meters) from the Gulf Power discharge ditch. At a station located over 1 mile downstream from the Gulf Power discharge ditch, the mortality of caged fish was greater than experienced by caged fish subjected to ambient river temperatures

at a control station upstream from the Gulf Power discharge ditch.

Salinity and dissolved oxygen in the area studied were suitable for fish survival. Control fish not subject to influences of the heated effluent survived. It is therefore concluded that at the point of discharge and for distances up to 1 mile downstream, the heated discharge from Gulf Power was increasing Escambia River water temperatures to a level which was lethal to fish life.

Thermal studies on July 20 showed that the heated discharge from Gulf Power increased river water temperatures 6° to 11°F for a distance of at least 0.5 miles. This band of heated water extended fully across the river to depths of 4 feet. These elevated river water temperatures constitute a thermal block; and adult, fingerling, or fry of fish swimming or drifting through the zone of heated water would be subject to thermal shock and high mortality.

The Monsanto outfall increased near-surface water temperatures 2°F in a very localized area of the river and the effects of this increase are considered to be insignificant. Therefore, no biological studies were conducted in the vicinity of the Monsanto outfall.

Table 1

ESCAMBIA RIVER TEMPERATURE STUDY STATIONS - JULY 20, 1972

Escambia #1	- at Channel Marker #20 (Escambia River mouth)
Escambia #2	- 1,100 yards upstream from mouth (at point of land on seaward side of southwest channel opening)
Escambia #3	- 2,100 yards upstream from mouth
Escambia #4	- 3,100 yards upstream from mouth
Escambia #5	- 3,600 yards upstream from mouth
Escambia #6	- 3,900 yards upstream from mouth
Escambia #7	- 4,100 yards upstream from mouth
Escambia #8	- 4,300 yards upstream from mouth
Gulf Power Ditch	- 4,400 yards upstream from mouth
Escambia #9	- 4,500 yards upstream from mouth
Escambia #10	- 4,700 yards upstream from mouth
Escambia #11	- 5,000 yards upstream from mouth
Escambia #12	- 5,500 yards upstream from mouth
Escambia #13	- 6,700 yards upstream from mouth
Escambia #14	- 8,700 yards upstream from mouth
Escambia #15	- 9,700 yards upstream from mouth
Escambia #16	- 10,200 yards upstream from mouth
Escambia #17	- 10,500 yards upstream from mouth
Monsanto Outfall	- 10,600 yards upstream from mouth
Escambia #18	- 10,700 yards upstream from mouth

Table 2

CONDUCTIVITY (μmho) AT STATIONS ON THE ESCAMBIA RIVER
LOW TIDE - JULY 20, 1972

Station	Depth				
	Surface	5 Feet	10 Feet	15 Feet	1 Foot Above Bottom
1	3,500	---	---	---	12,000 (12')[1]
2	3,100	4,000	---	---	13,000 (12')
3	2,500	3,100	5,600	---	36,000 (15')
4	1,400	2,000	3,000	6,500	20,000 (20')
5	2,000	1,700	---	---	2,800 (12')
6	2,000	1,450	---	---	6,500 (12')
7	1,900	1,800	---	---	6,100
8	2,200	1,300	---	---	6,100
9	900	1,650	2,000	---	7,000
10	900	1,000	2,100	---	6,000
11	750	1,000	---	---	2,300
12	900	1,100	---	---	3,500
13	400	400	450	---	2,000
14	---	---	---	---	---
15	---	---	---	---	---
16	120	---	---	---	130
17	130	---	---	---	110
18	80	---	---	---	80

[1] Numbers in parentheses represent maximum depth at sample site.

Table 3

CONDUCTIVITY (μmho) AT STATIONS ON THE ESCAMBIA RIVER
HIGH TIDE - JULY 20, 1972

Station	Depth				
	Surface	5 Feet	10 Feet	15 Feet	1 Foot Above Bottom
1	8,750	---	---	---	13,400 (10')[1]
2	5,900	9,000	---	---	17,000
3	4,500	5,000	16,000	---	25,000 (15')
4	3,300	---	13,000	16,500	24,000
5	3,450	3,800	---	---	17,000 (12')
6	---	---	---	---	---
7	3,050	---	10,500	---	15,000 (20')
8	3,700	---	9,500	---	12,000
9	1,950	---	6,200	---	14,000
10	1,675	---	4,000	---	14,000
11	1,390	---	3,700	---	14,500 (13')
12	575	1,160	9,500	---	14,000 (14')
13	700	---	3,200	---	11,000 (15')
14	440	---	2,100	---	8,750 (15')
15	180	---	875	2,800	9,000 (20')
16	240	---	350	650	5,500 (20')
17	325	220	---	---	970 (13')
18	90	---	---	---	90

[1] Numbers in parentheses represent maximum depth at sample site.

Table 4

SEDIMENT PARTICLE SIZE DISTRIBUTION AND ORGANIC CONTENT
(PERCENT TOTAL DRY WEIGHT) AT STATIONS ON THE ESCAMBIA RIVER
UPSTREAM AND DOWNSTREAM FROM GULF POWER EFFLUENT DITCH - SEPTEMBER 27, 1972

Particle Size	Above Gulf Power	Below Gulf Power
Fine Gravel	4.3	2.4
Coarse Sand	3.3	2.2
Medium Sand	24.8	19.1
Fine Sand	13.5	9.5
Silt	27.4	36.8
Clay	5.9	8.3
Organic Content	20.8	21.7

Table 5

NUMBER OF TAXA AND NUMBER OF INDIVIDUALS OF MACROINVERTEBRATES COLLECTED WITH A PONAR GRAB UPSTREAM AND DOWNSTREAM FROM THE GULF POWER EFFLUENT DITCH

	Number of Taxa		Number of Individuals	
	Upstream	Downstream	Upstream	Downstream
	5	4	23	4
	6	4	11	10
	4	4	6	70
Total	15	12	40	84
Mean	5	4	13	28
t	1.72		0.68	
$t_{.05}$				

Table 6

MACROINVERTEBRATES COLLECTED FROM THE ESCAMBIA RIVER
SEPTEMBER 27, 1972

	Above Gulf Power	Below Gulf Power
Rhynchocoela		
Anopea	5	50
Annelida		
Polychaeta	23	16
Oligochaeta	1	13
Arthopoda		
Crustacea		
Cirripedia		
Balanomorpha		
Balanus sp.	8	14
Tanaidacea		
Leptochelia sp.	2	2
Isopoda		
Asellus sp.	1	3
Amphipoda		
Gammarus mucronatus	7	
Melita sp.	1	
Corophium sp.	10	
Decapoda		
Caridea		
Palaemonetes sp.	1	4
Brachyura		
Caridea		
Rhithropanopoeus harrisi	8	8
Callinectes sp.	6	12
Ocypodidae		
Uca sp.	1	1
Insecta		
Odonata		
Zygoptera		
Enallogma sp.		1
Trichoptera		
Oecetis sp.	1	
Diptera		
Ablabesmyia jonta	1	2
Endochironomus nigricans	1	
Polypedilum illinoense	1	
Dicrotendipes nervosus		1
Coelotanypus concinmus	2	

Table 6
(Continued)

Taxa	Above Gulf Power	Below Gulf Power
Mollusca		
Gastropoda		
Neritina reclivata	20	22
Bivalvia		1
Mytilus sp.	10	
Mulinia sp.	3	
Chordata		
Osteichthyes		
Gobiosoma bosci	1	1
Paralichthys lethostigma	1	
Total Number of Individuals	115	151
Total Number of Taxa	23	15

Table 7

PERCENT COMPOSITION OF ALGAE GROUPS IN THE ESCAMBIA RIVER - SEPTEMBER 27, 1972

Location	Temperature (°F)	Filamentous Blue-Greens	Coccoid Greens	Filamentous Greens	Green Flagellates	Centric Shells	Live Centrics	Pennate Shells	Live Pennates
100 yards above Gulf Power outfall	82.5	12	01	50	02	02	01	04	28
40 yards up Gulf Power ditch	180.17	83	00	00	02	08	01	02	04
50 yards below Gulf Power outfall	97.0	48	08	00	00	02	01	11	35
250 yards below Gulf Power outfall	94.0	43	00	02	02	02	01	13	36

Table 8

WATER TEMPERATURES (°F) AT IN SITU BIOASSAY STUDY STATIONS
ESCAMBIA RIVER, SEPTEMBER 10-OCTOBER 10, 1972

Date	Time *	Station I		Station II			Station III			Station IV			Station V		Station VI		
		1'	4'	1'	4'	9'	1'	4'	9'	1'	4'	9'	1'	4'	1'	4'	9'
9/27	1000			100.2			100.2			82.5							
9/29	1500			101.8			102.0						84.6				
9/30	0915			84.6	93.2	93.7	93.4	93.7	93.9				81.1				
10/2	1430						83.3	91.6	92.5				79.9	77.0	78.8	77.0	79.9
10/3	1145	82.6	82.4	83.1	86.0	94.3	95.5	95.7	95.7	78.4	78.6		80.4	81.7	80.1	78.1	79.9
10/4	0930			77.5	75.4	91.8							74.8	75.7			
10/5	1430	80.8	80.1	81.0	92.4				96.8	79.2	79.2		78.8	78.4			
10/6	0830	79.2	78.3	80.6	96.4	96.8				79.5	83.7	78.8	79.8	80.4			
10/7	0830	75.9	78.4	75.2	86.2	82.2				75.2	79.8	80.2					
10/10	1400	83.7	85.1	95.9	95.7	95.9	95.7	95.7		79.5	79.0	80.1	76.6	76.6			

* Time indicated when first measurement taken; all measurements finished within one hour.

Table 9

SALINITY (parts per thousand) AT IN SITU BIOASSAY STUDY STATIONS
ESCAMBIA RIVER, SEPTEMBER 29-OCTOBER 10, 1972

Date	Time	Station I		Station II			Station III			Station IV			Station V		Station VI		
	*	1'	4'	1'	4'	9'	1'	4'	9'	1'	4'	9'	1'	4'	1'	4'	9'
9/29	1500			3									3				
9/30	0915			4			12						4				
10/2	1430			3	11								2	2	3	3	
10/3	1145	9	9	5	7		13	13		4	6		5	5	3	3	10
10/4	0930																
10/5	1430	5	18	3	12	12				3	7		3	6			
10/6	0830	6	15	4	7	10				4	5	18	5	12			
10/7	0830	4	18	4	11	19				4	4	11					
10/10	1400	11	20	18	18	17				8	8	21	8	10			

* Time indicated when first measurement taken; all measurements finished within one hour.

Table 10

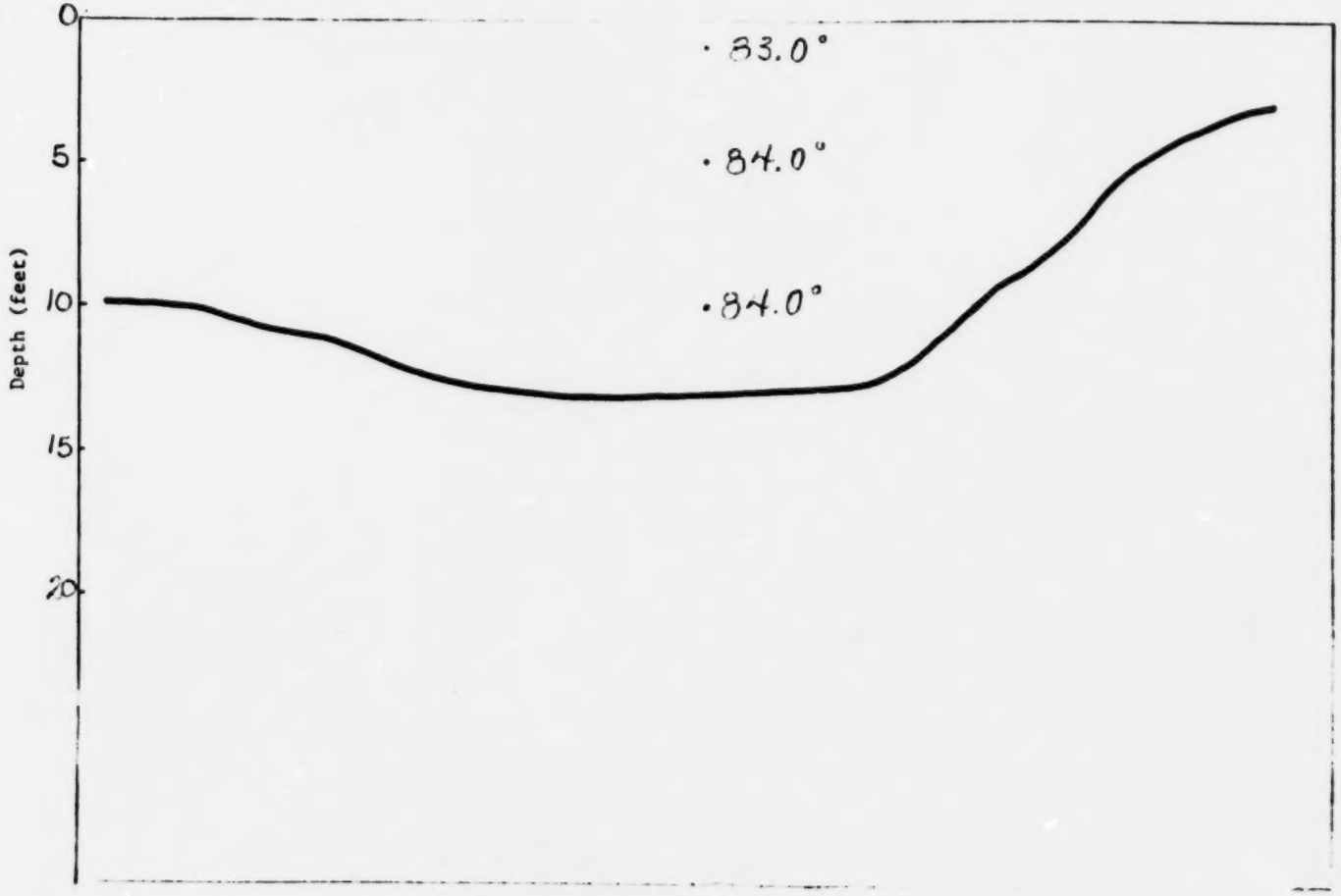
SURVIVAL OF CAGED FISH AT 4-FOOT WATER DEPTH AT THREE STATIONS ON THE ESCAMBIA RIVER - OCTOBER 1972

Date	Time	Station I		Station II		Station IV	
		Exposure Time (hours)	Live Fish	Exposure Time (hours)	Live Fish	Exposure Time (hours)	Live Fish
10/3	1145	0	10	0	10	0	10
10/4	0930	24	10	24	10	24	10
10/5	1430	48	8	48	2	48	10
10/6	0830	72	7	--*	--*	72	10
10/7	0830	96	7	--	--	96	10

* Cage disappeared subsequent to 48-hour examination of fish.

Figure 3

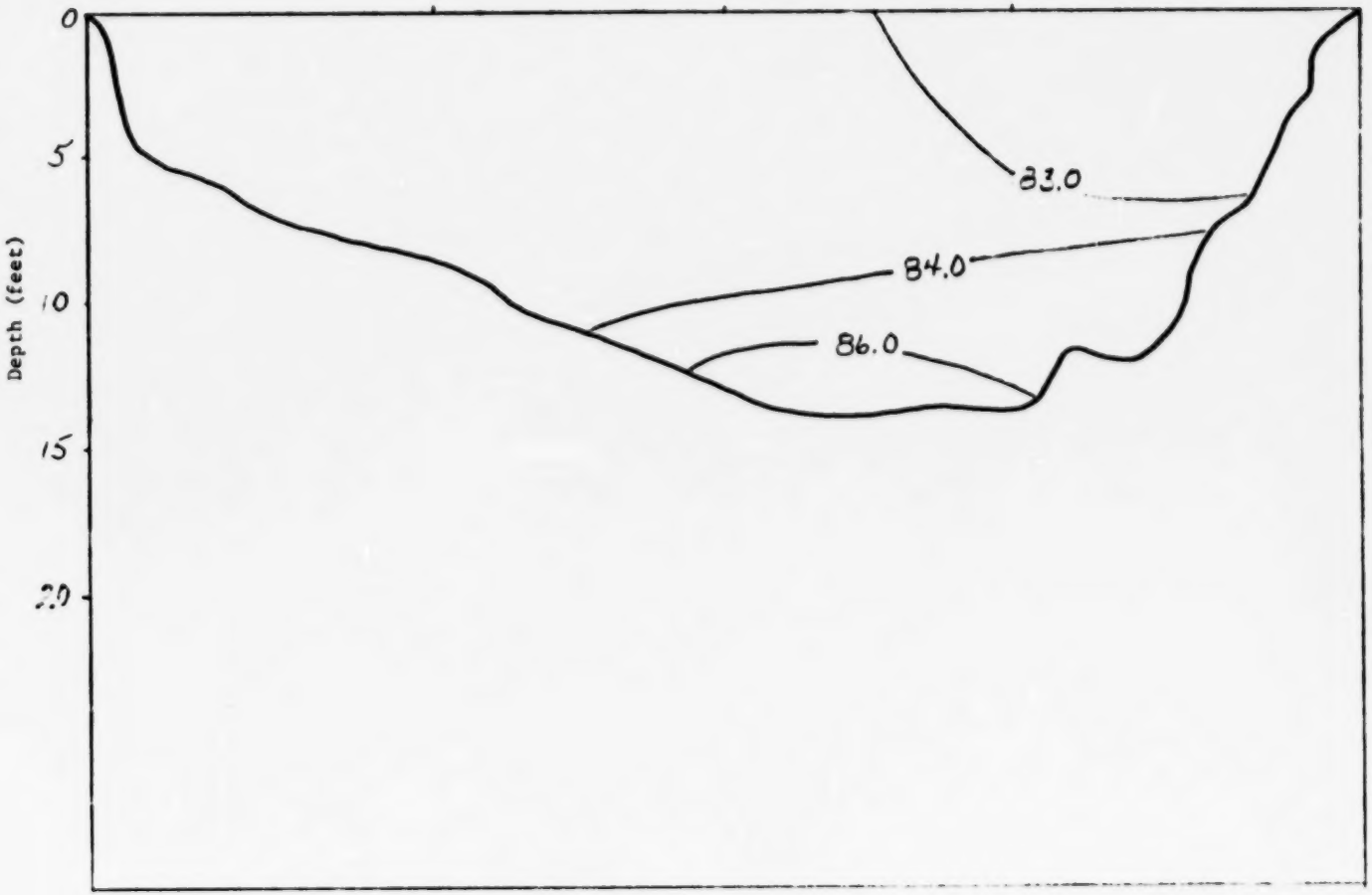
VERTICAL PROFILE OF WATER TEMPERATURE (°F) AT STATION 1 (CHANNEL MARKER #20)
ON THE ESCAMBIA RIVER DURING HIGH TIDE - JULY 20, 1972



Partial Cross Section of River
(facing downstream)

Figure 4

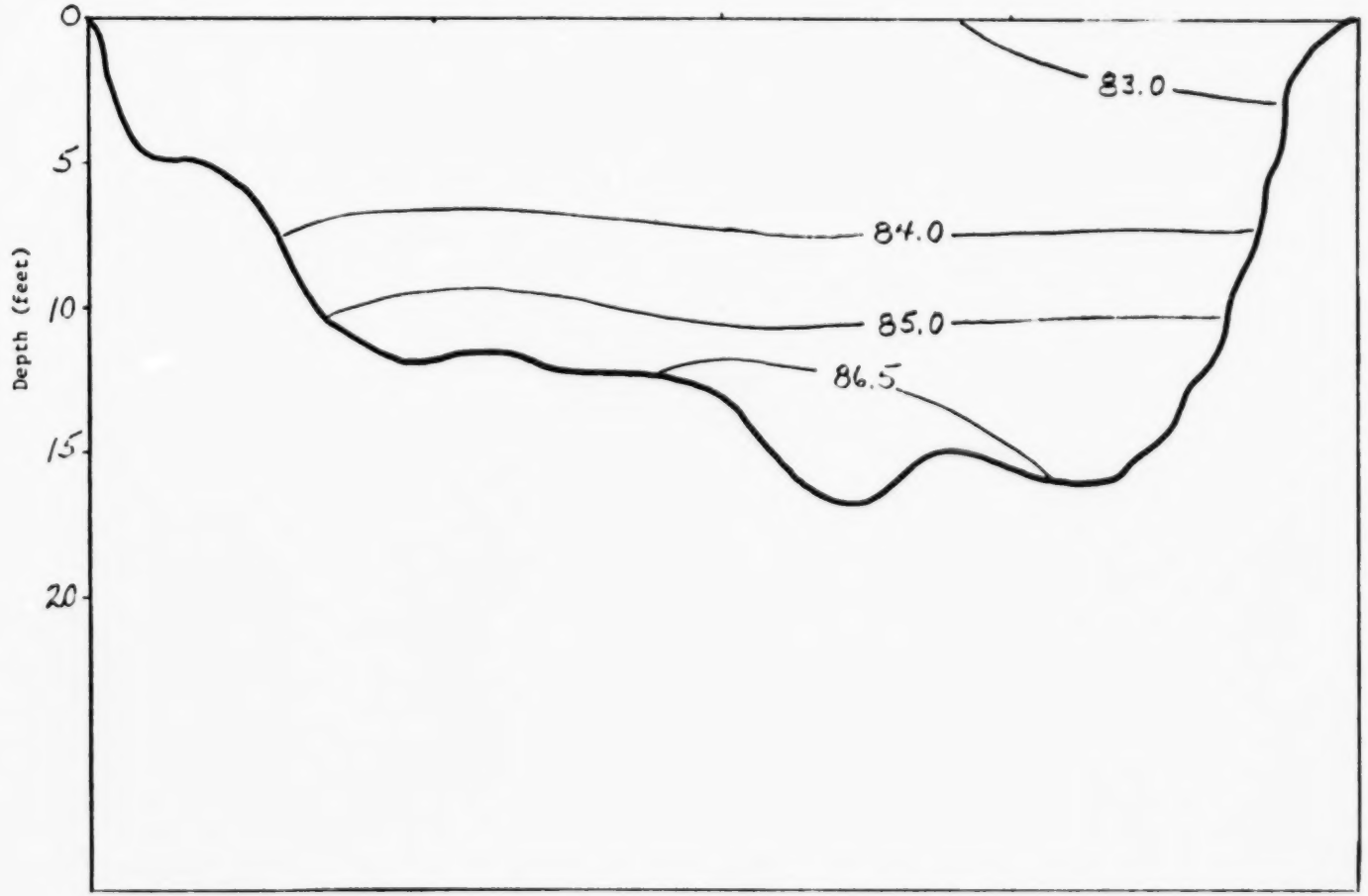
WATER TEMPERATURE (°F) AT STATION 2 ON THE ESCAMBIA RIVER DURING HIGH TIDE - JULY 20, 1972



Cross Section of River
(facing downstream)

Figure 5

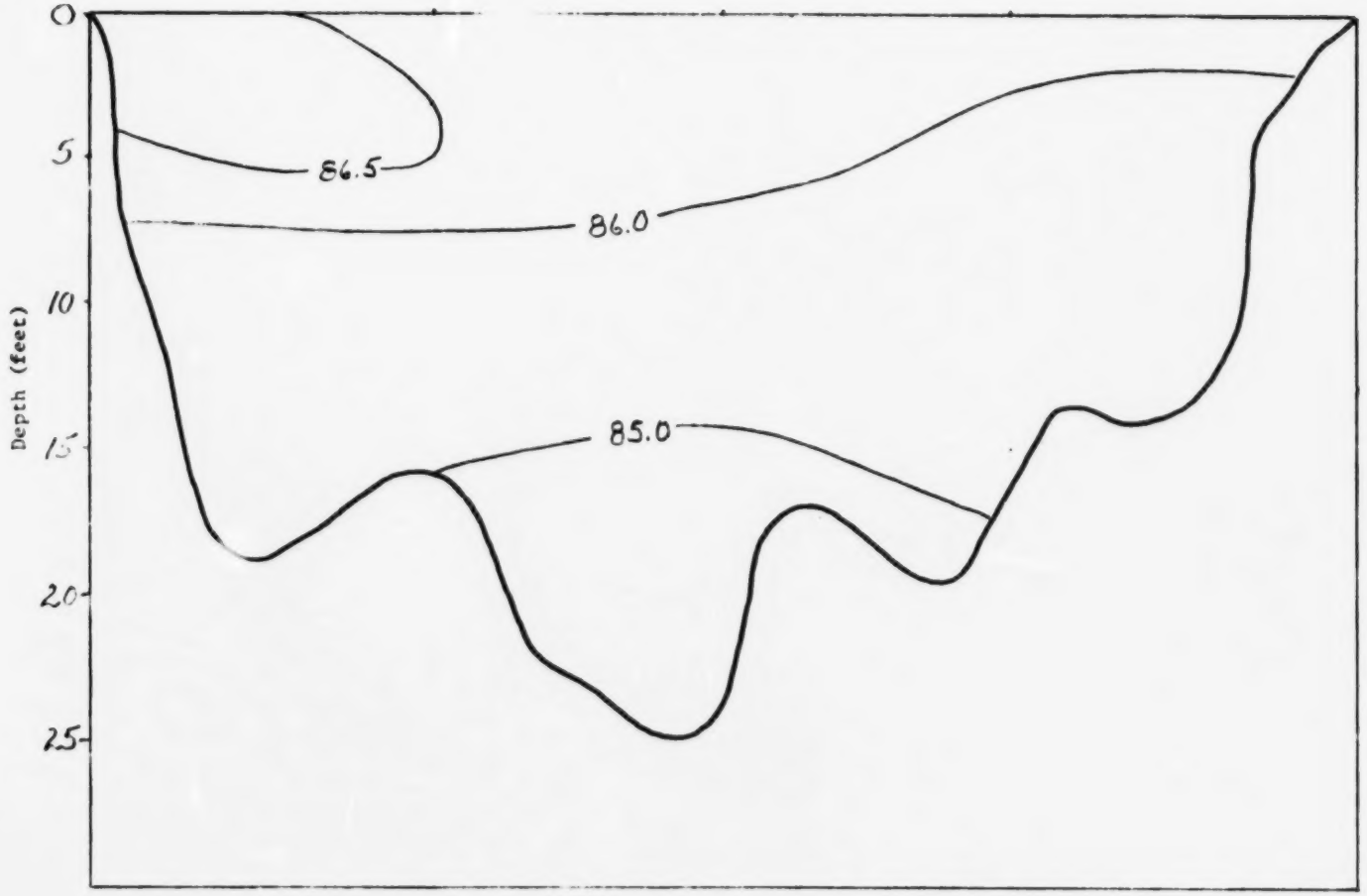
WATER TEMPERATURE (°F) AT STATION 3 ON THE ESCAMBIA RIVER DURING HIGH TIDE - JULY 20, 1972



Cross Section of River
(facing downstream)

Figure 6

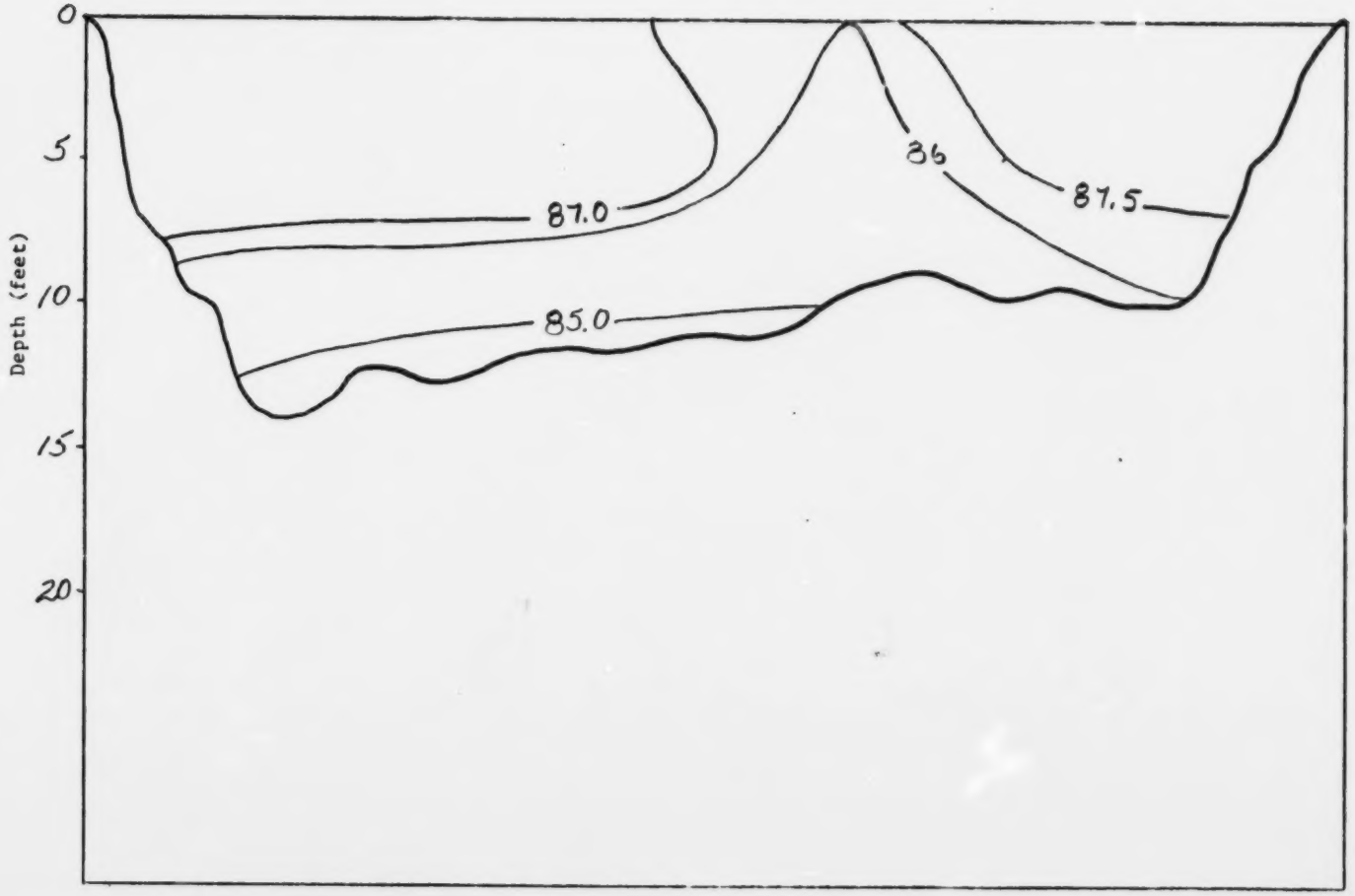
WATER TEMPERATURE (^{o}F) AT STATION 4 ON THE ESCAMBIA RIVER DURING HIGH TIDE - JULY 20, 1972



Cross Section of River
(facing downstream)

Figure 7

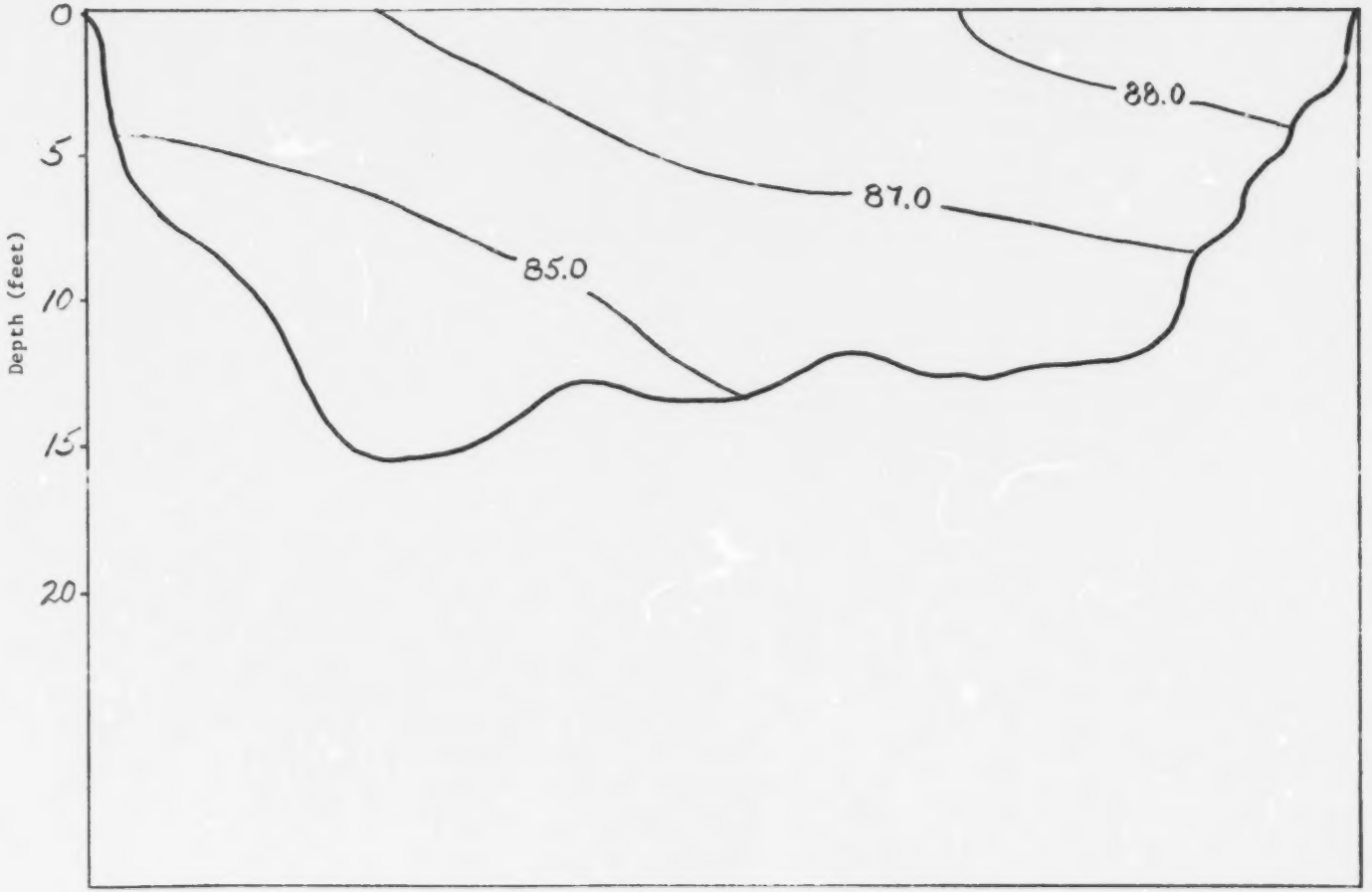
WATER TEMPERATURE (°F) AT STATION 5 ON THE ESCAMBIA RIVER DURING HIGH TIDE - JULY 20, 1972



Cross Section of River
(facing downstream)

Figure 8

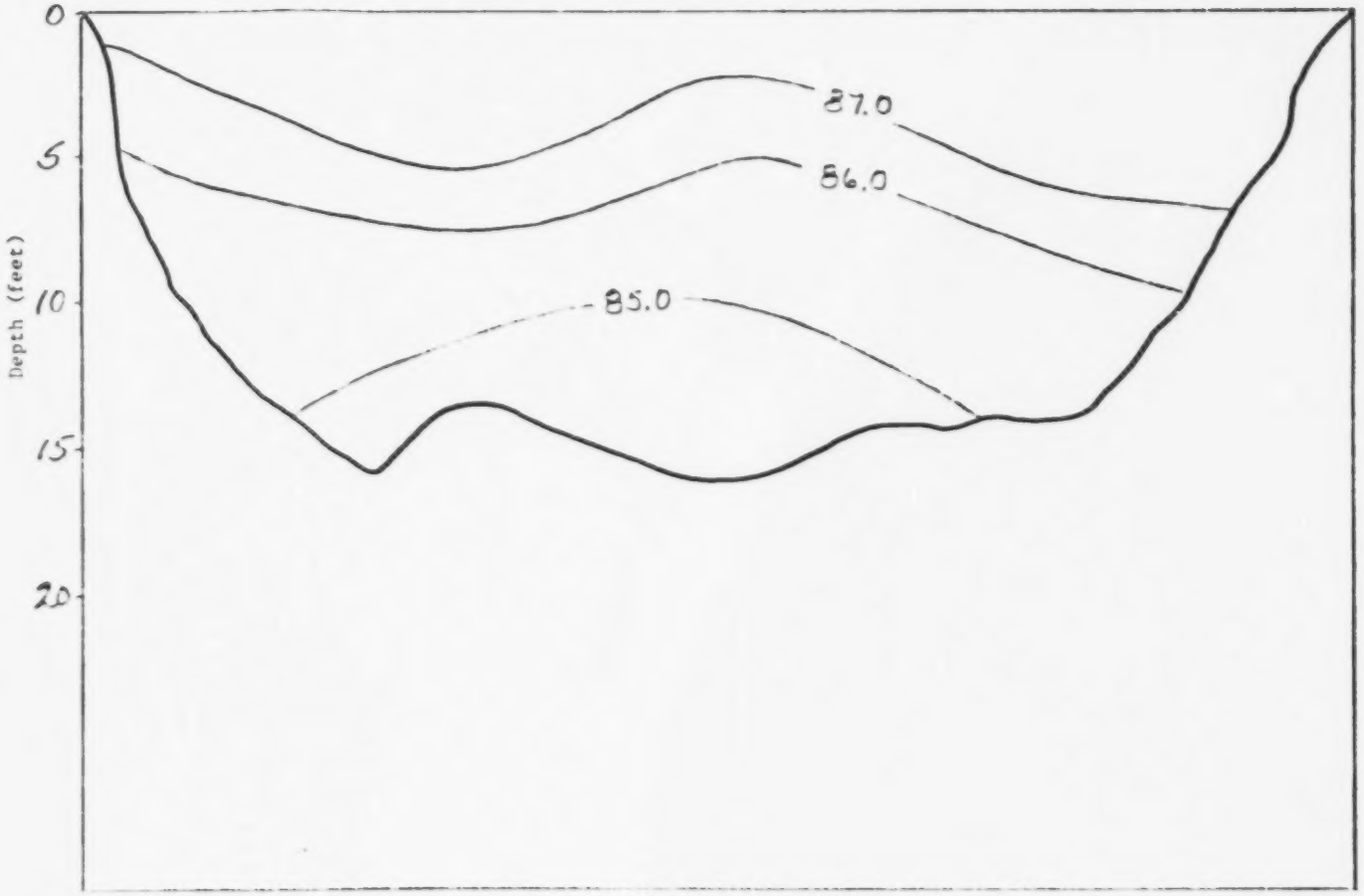
WATER TEMPERATURE (°F) AT STATION 6 ON THE ESCAMBIA RIVER DURING HIGH TIDE - JULY 20, 1972



Cross Section of River
(facing downstream)

Figure 9

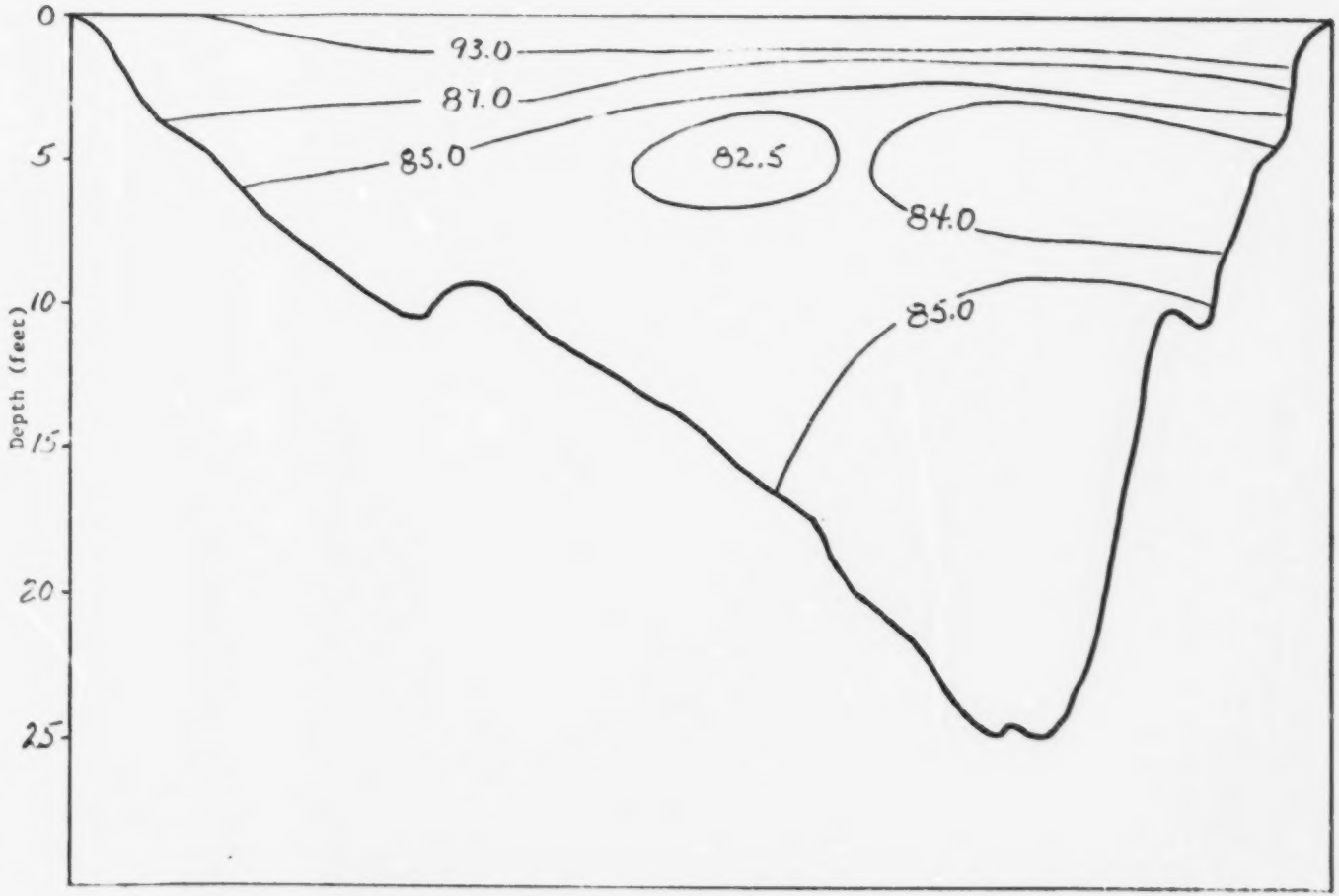
WATER TEMPERATURE (°F) AT STATION 7 ON THE ESCAMBIA RIVER DURING HIGH TIDE - JULY 20, 1972



Cross Section of River
(facing downstream)

Figure 10

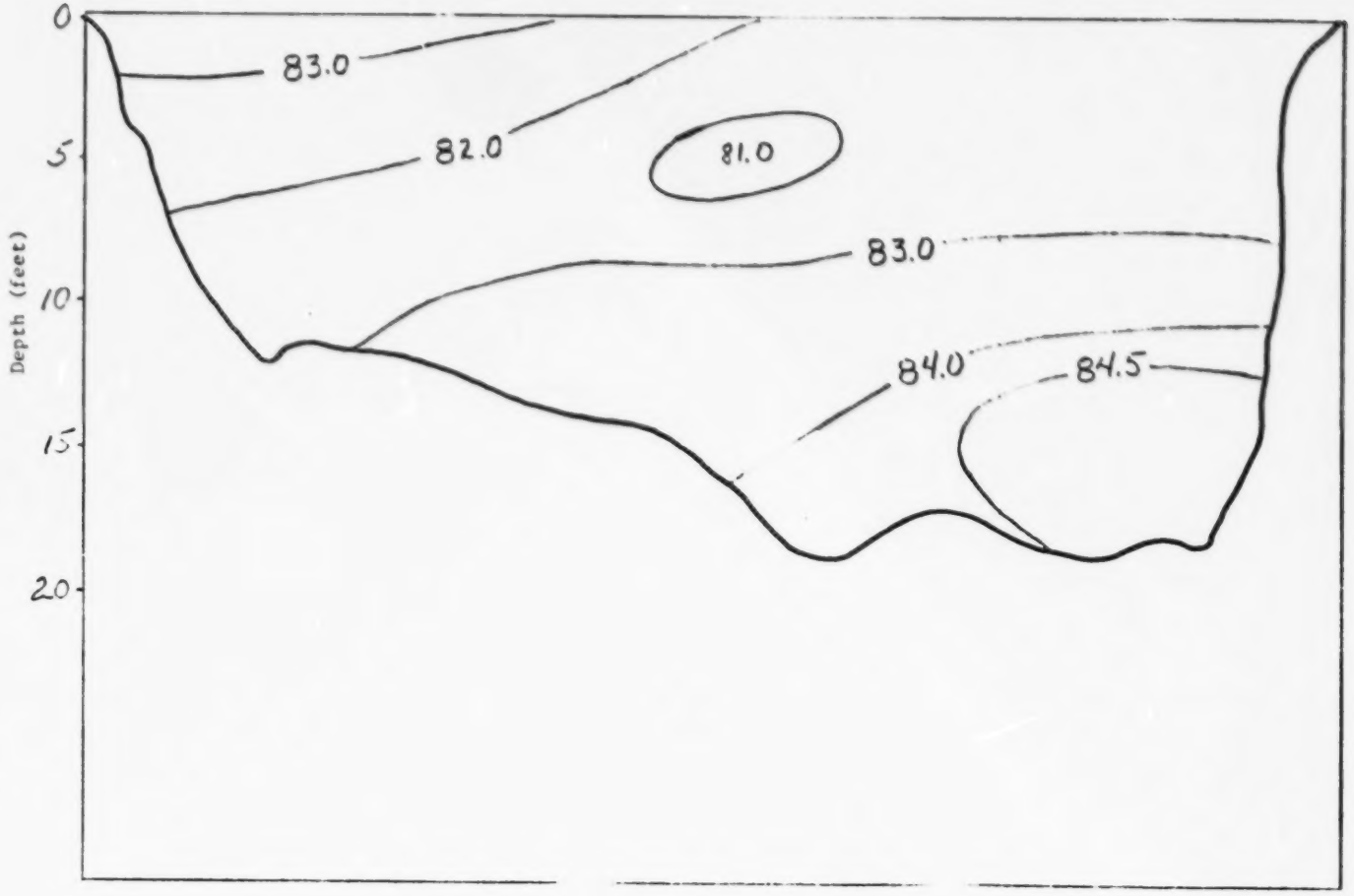
WATER TEMPERATURE (°F) AT STATION 8 ON THE ESCAMBIA RIVER DURING HIGH TIDE - JULY 20, 1972



Cross Section of River
(facing downstream)

Figure 11

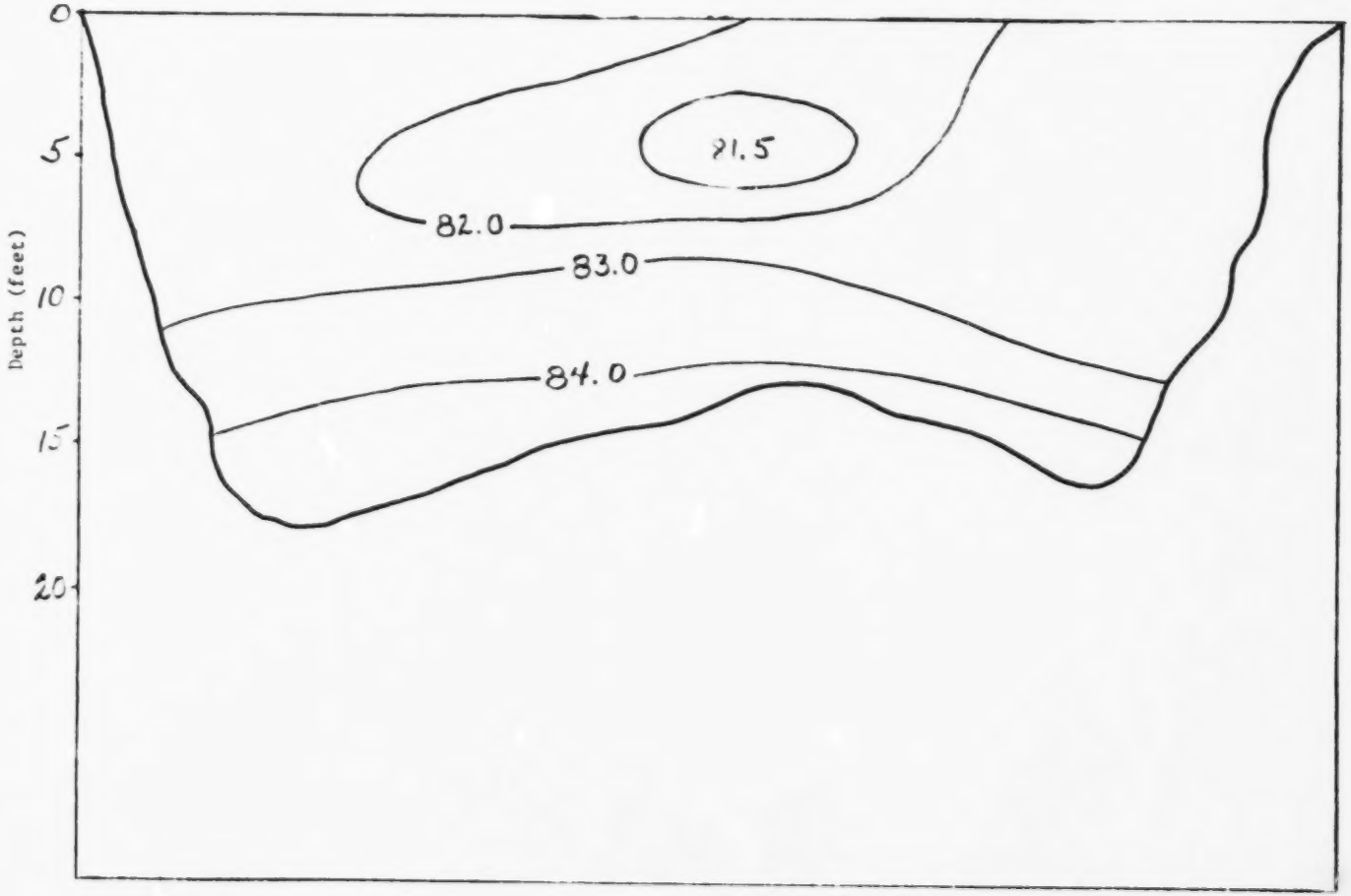
WATER TEMPERATURE (°F) AT STATION 9 ON THE ESCAMBIA RIVER DURING HIGH TIDE - JULY 20, 1972



Cross Section of River
(facing downstream)

Figure 12

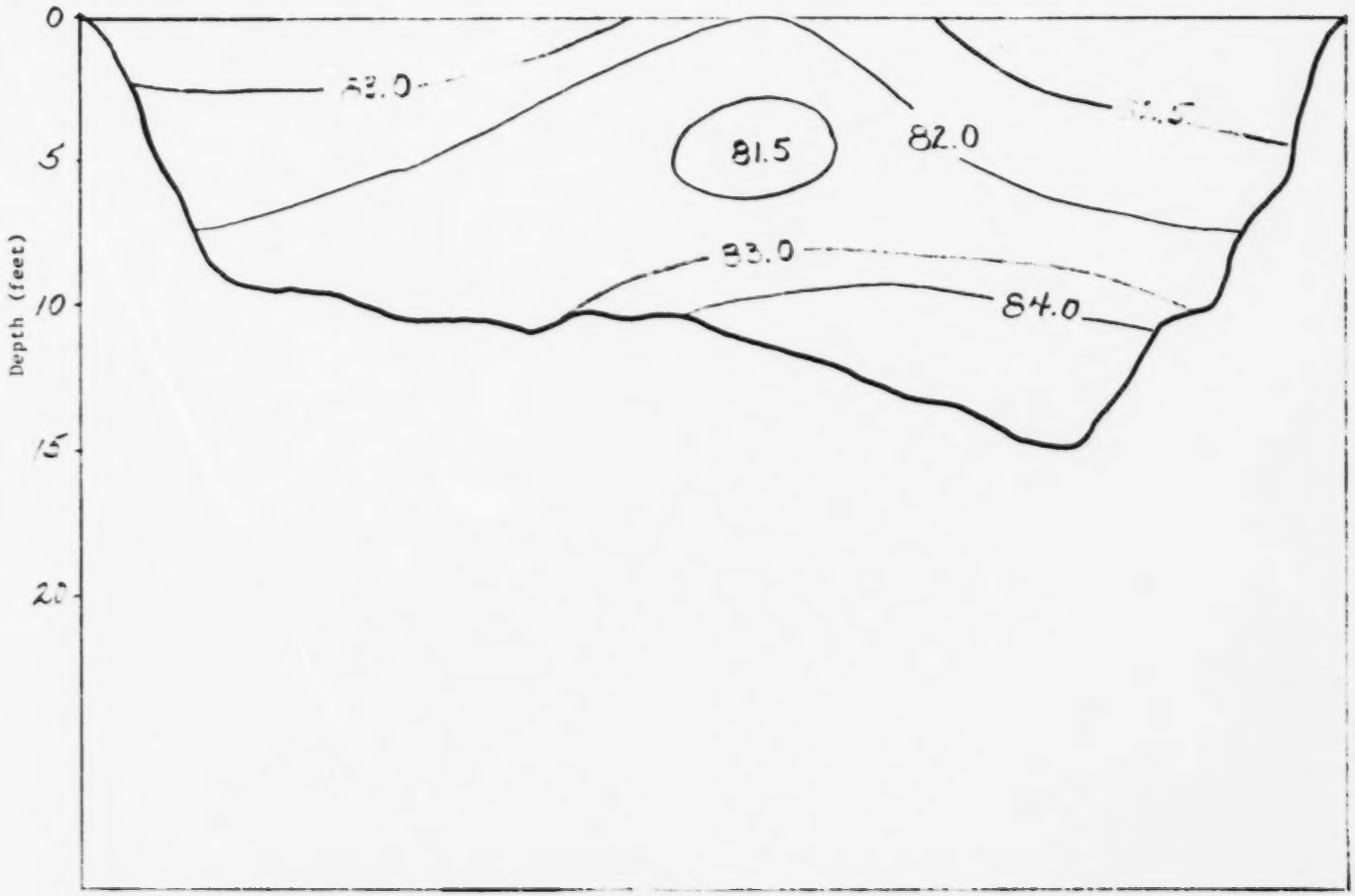
WATER TEMPERATURE (°F) AT STATION 10 ON THE ESCAMBIA RIVER DURING HIGH TIDE - JULY 20, 1972



Cross Section of River
(facing downstream)

Figure 13

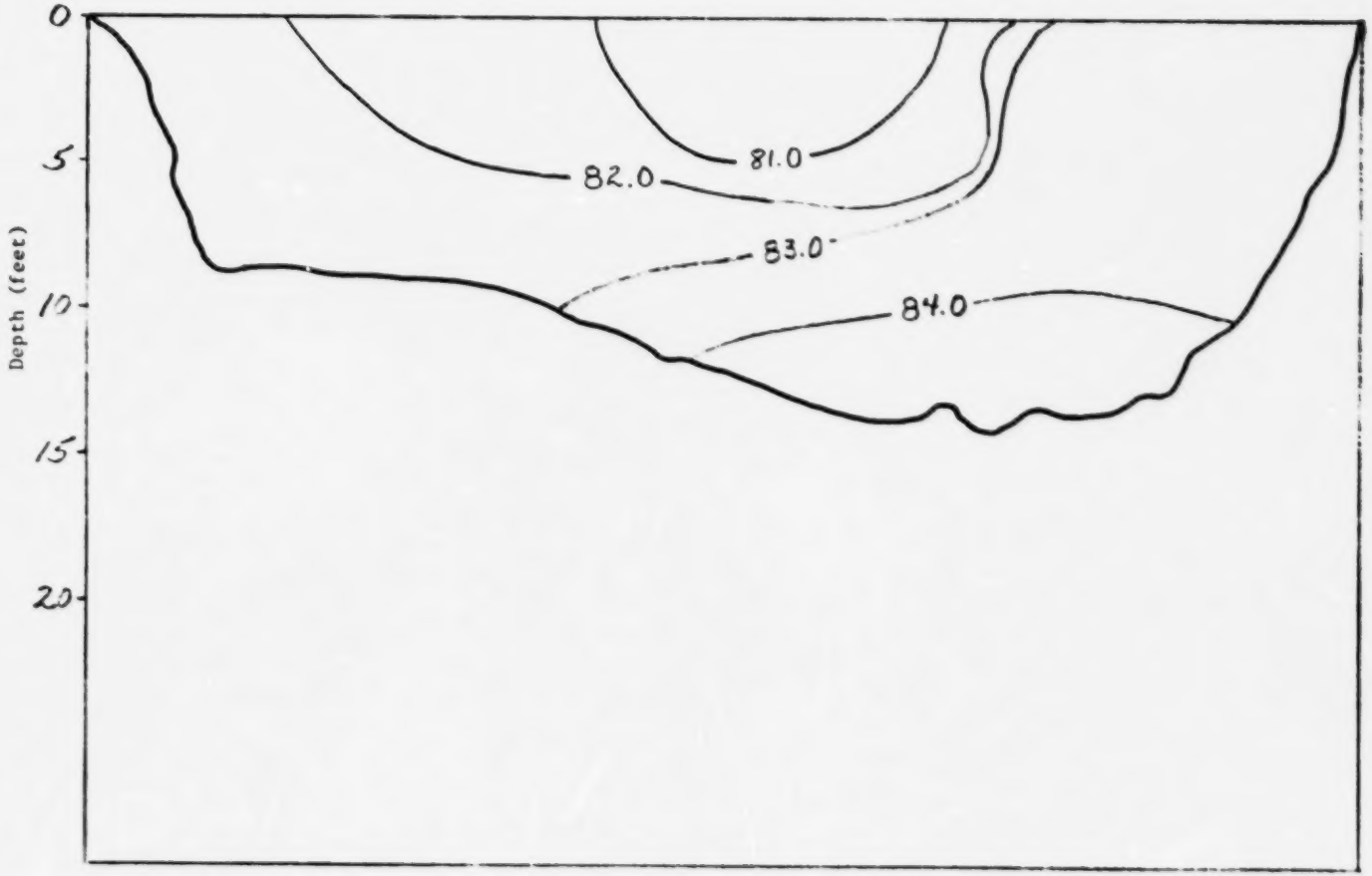
WATER TEMPERATURE (°F) AT STATION 11 ON THE ESCAMBIA RIVER DURING HIGH TIDE - JULY 20, 1972



Cross Section of River
(facing downstream)

Figure 14

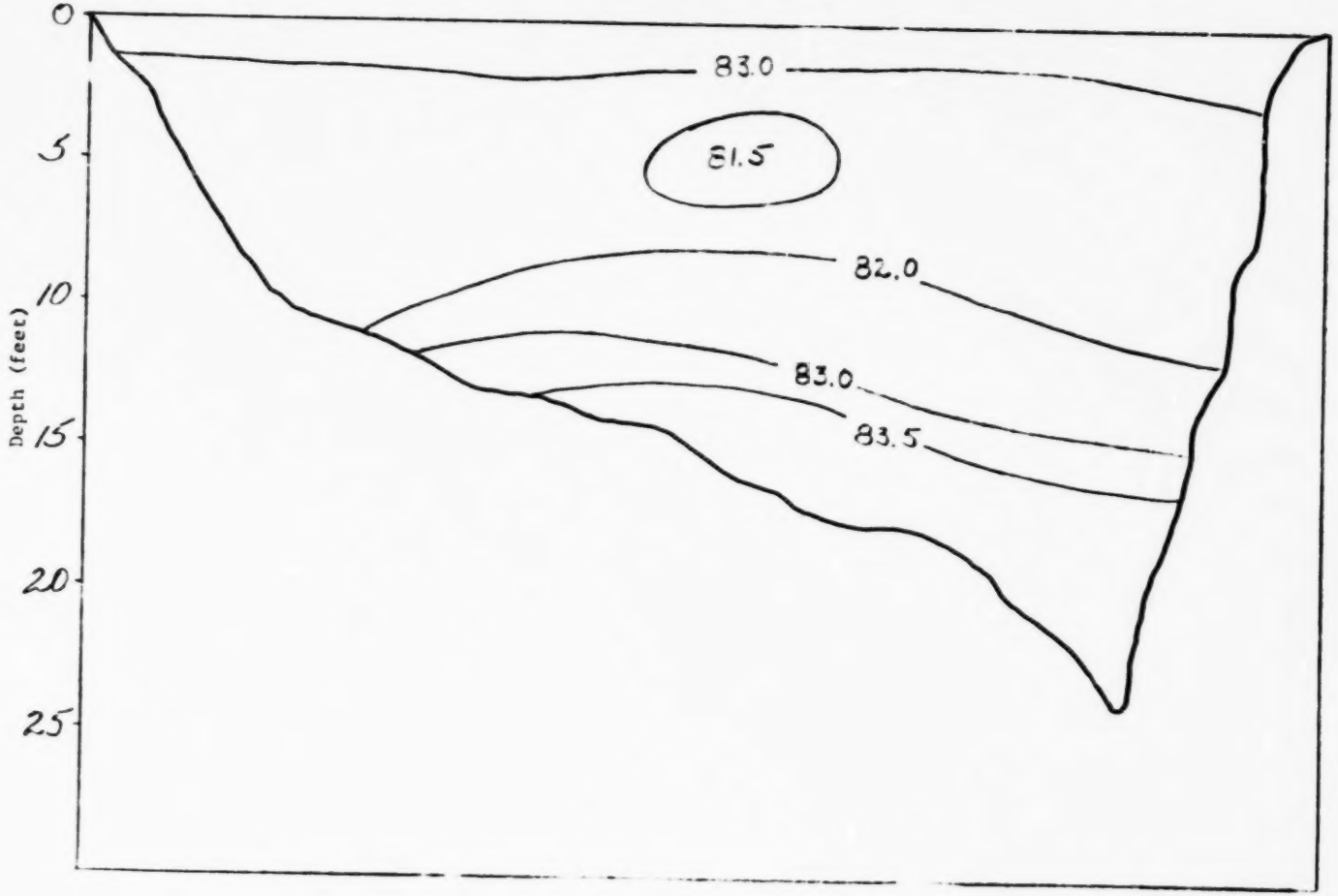
WATER TEMPERATURE (°F) AT STATION 12 ON THE ESCAMBIA RIVER DURING HIGH TIDE - JULY 20, 1972



Cross Section of River
(facing downstream)

Figure 15

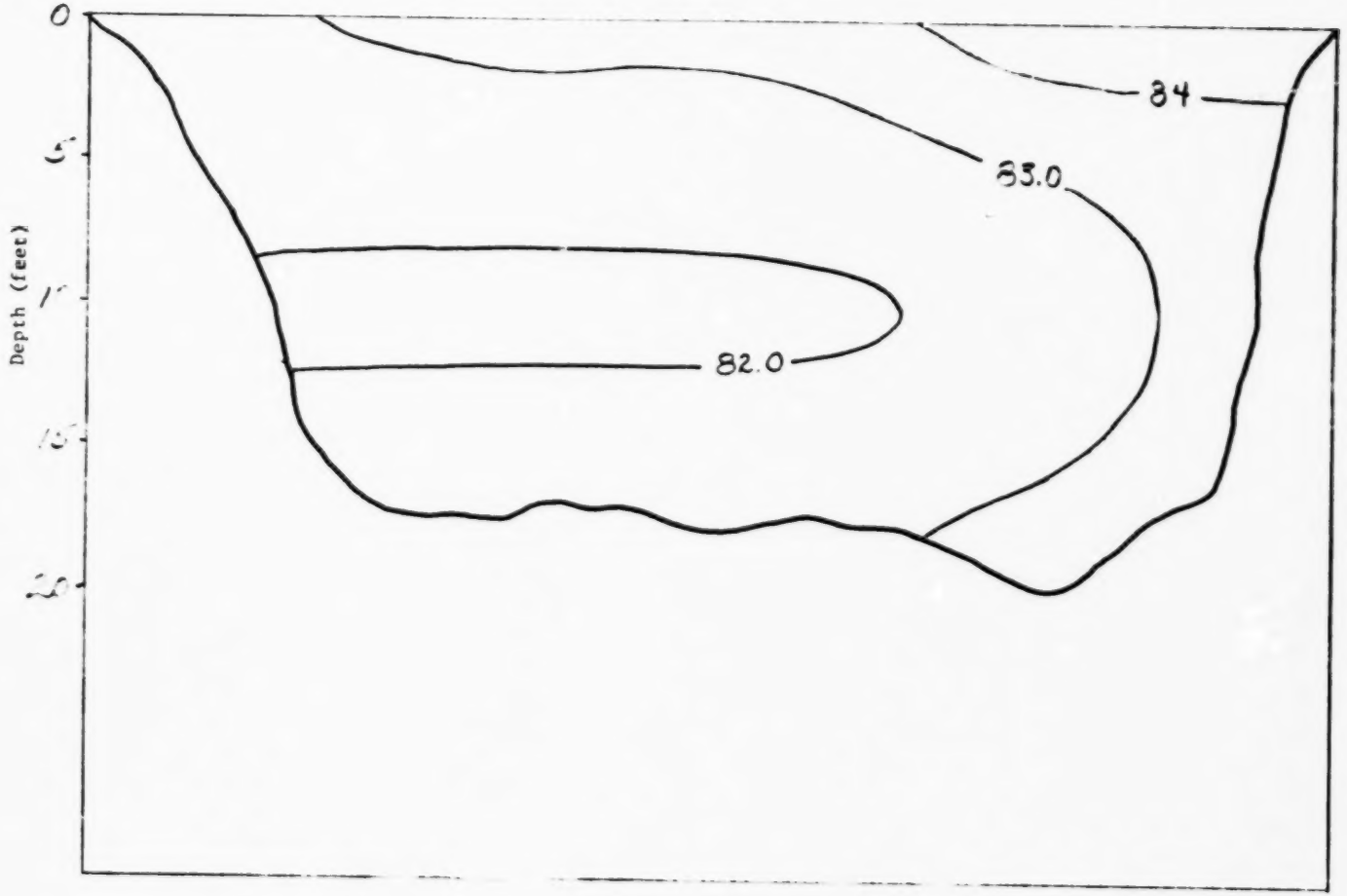
WATER TEMPERATURE (°F) AT STATION 13 ON THE ESCAMBIA RIVER DURING HIGH TIDE - JULY 20, 1972



Cross Section of River
(facing downstream)

Figure 16

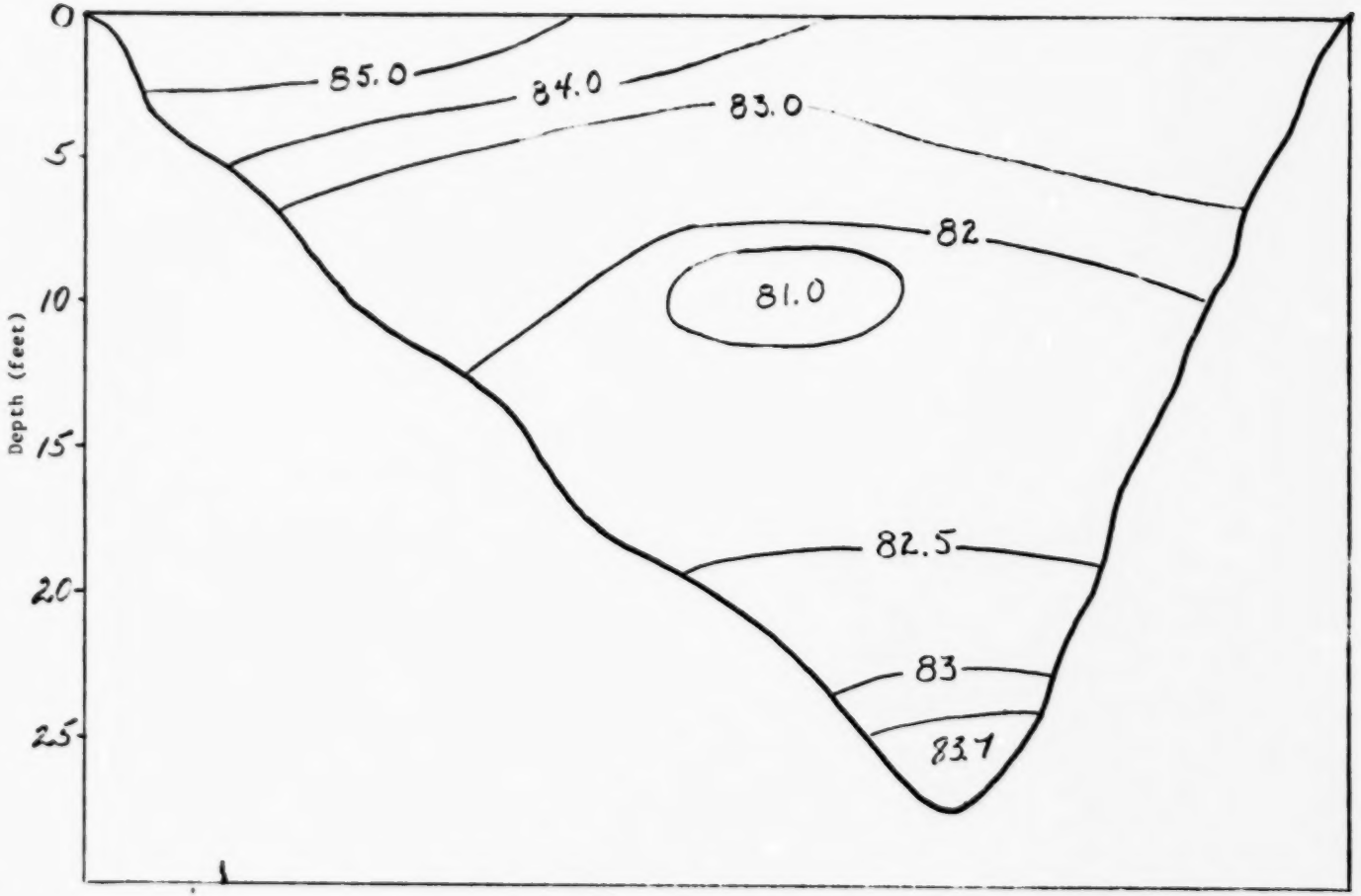
WATER TEMPERATURE (°F) AT STATION 14 ON THE ESCAMBIA RIVER DURING HIGH TIDE - JULY 20, 1972



Cross Section of River
(facing downstream)

Figure 17

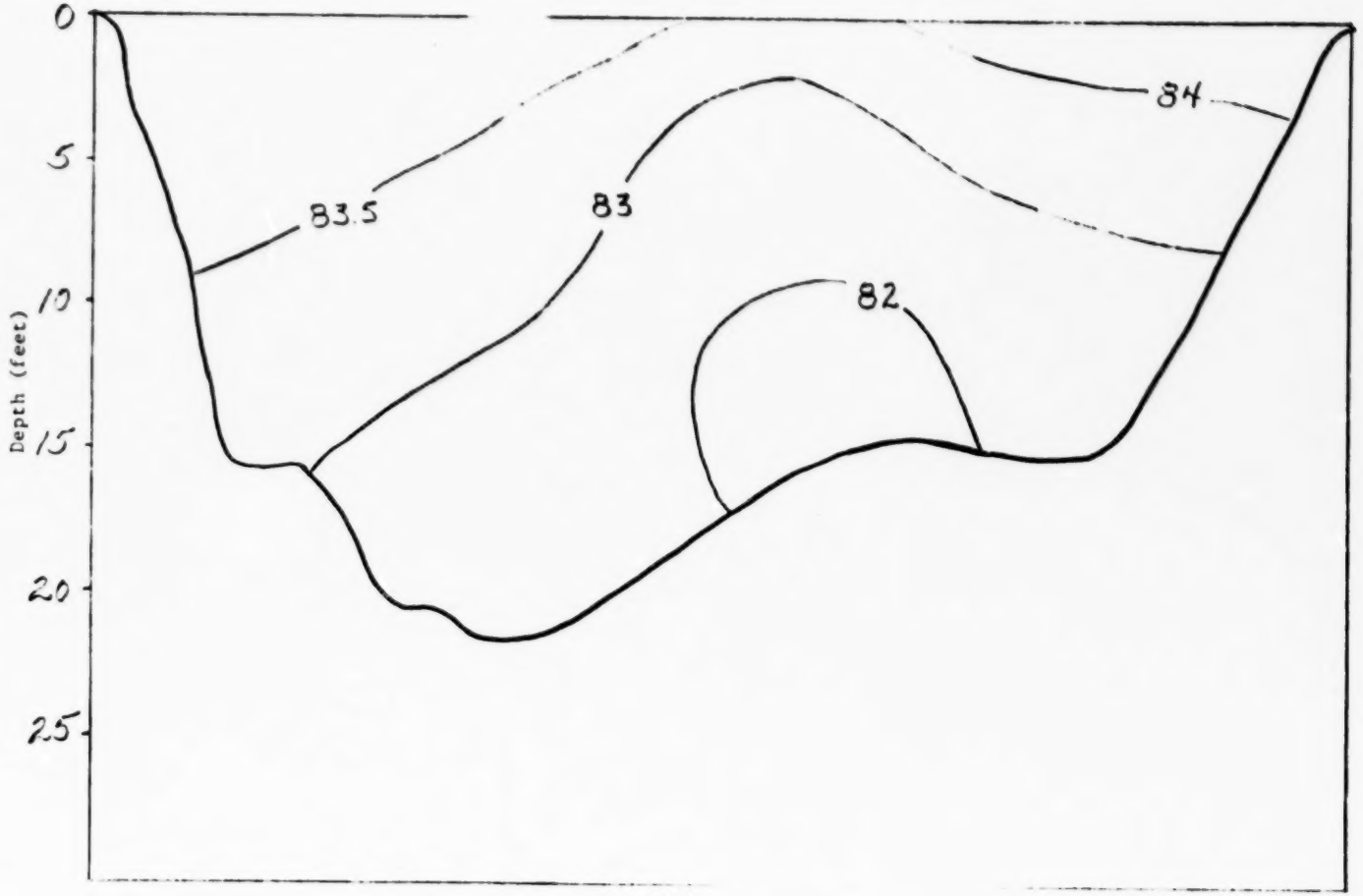
WATER TEMPERATURE (^{o}F) AT STATION 15 ON THE ESCAMBIA RIVER DURING HIGH TIDE - JULY 20, 1972



Cross Section of River
(facing downstream)

Figure 18

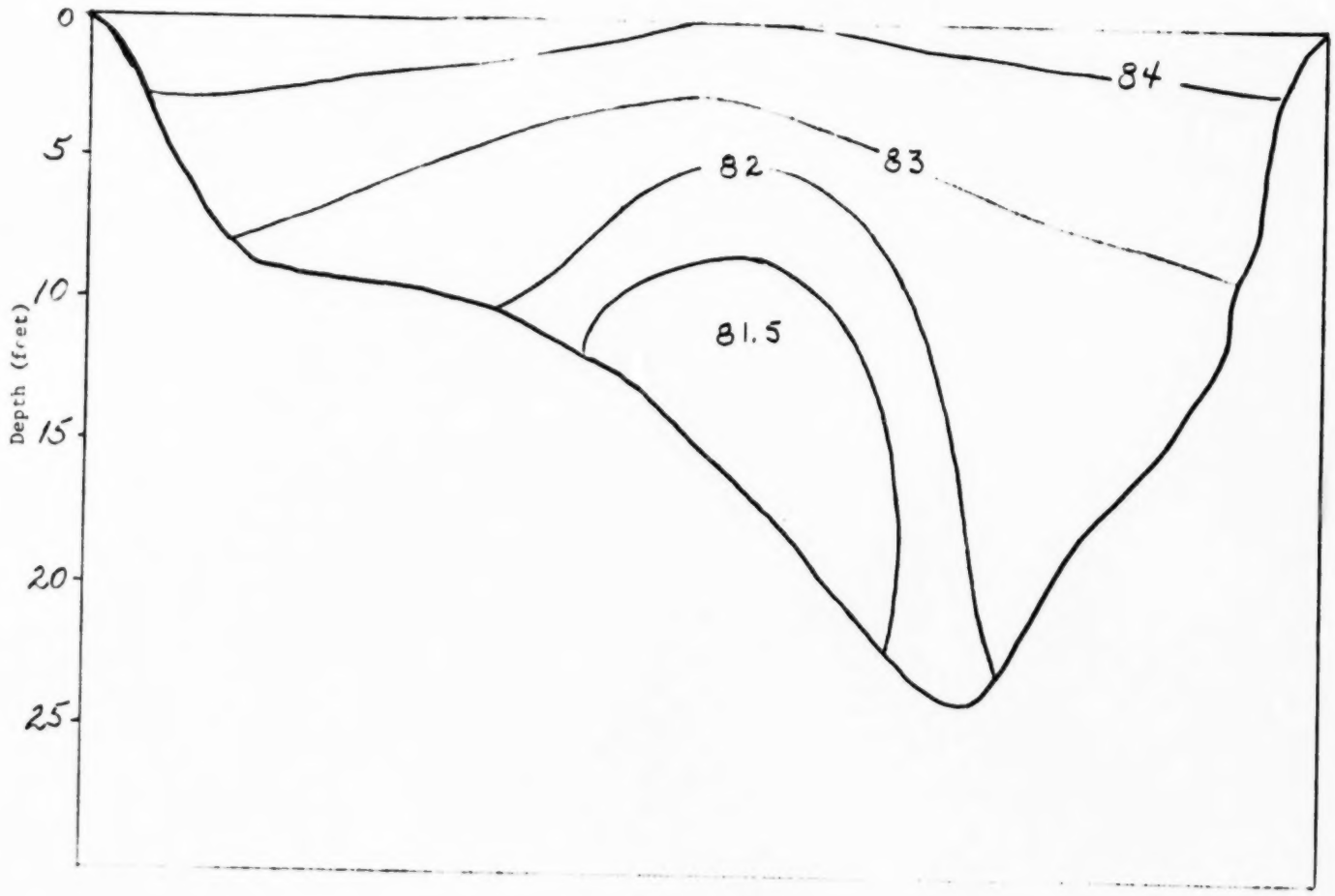
WATER TEMPERATURE (°F) AT STATION 16 ON THE ESCAMBIA RIVER DURING HIGH TIDE - JULY 20, 1972



Cross Section of River
(facing downstream)

Figure 19

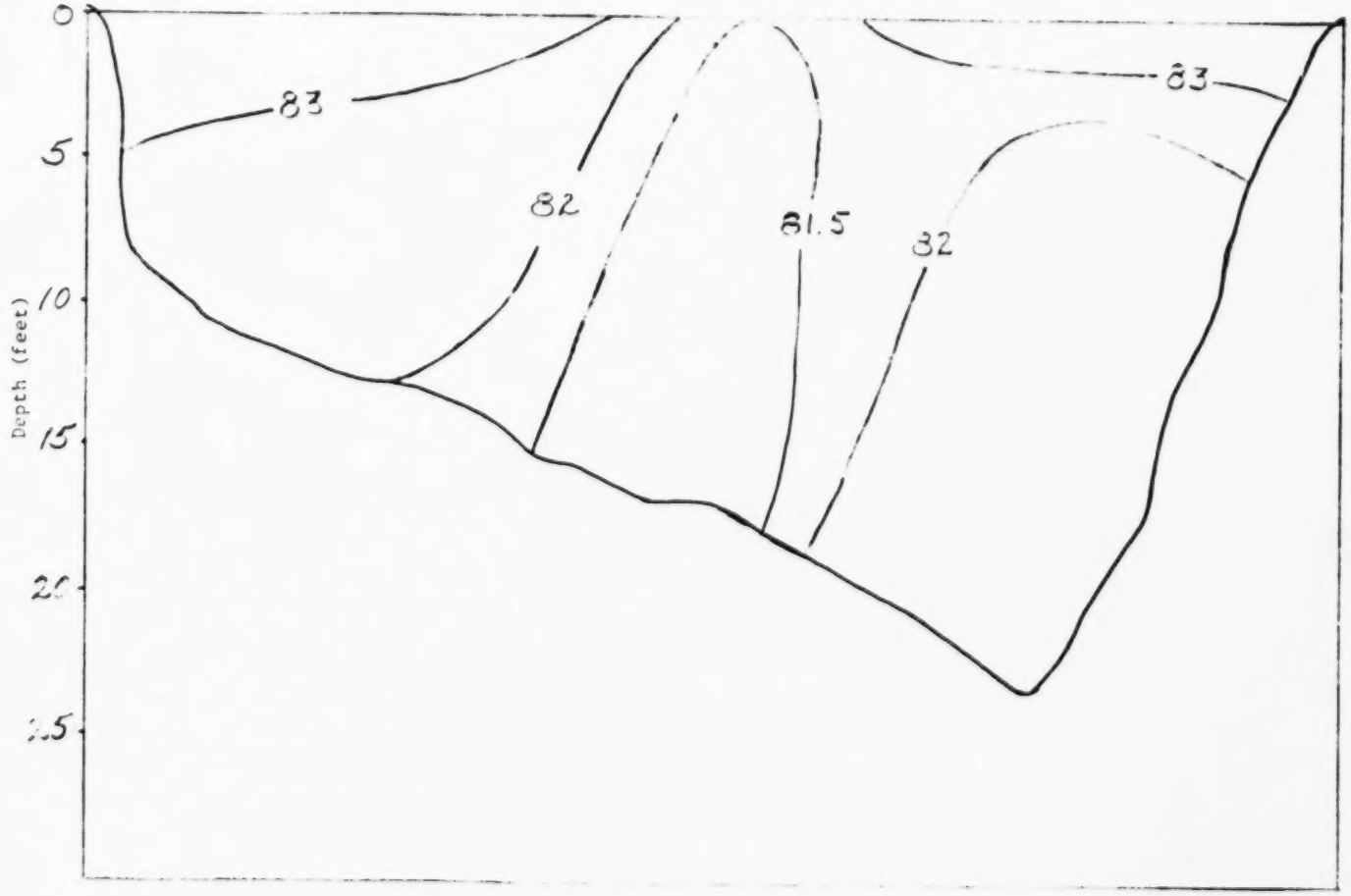
WATER TEMPERATURE (°F) AT STATION 17 ON THE ESCAMBIA RIVER DURING HIGH TIDE - JULY 20, 1972



Cross Section of River
(facing downstream)

Figure 20

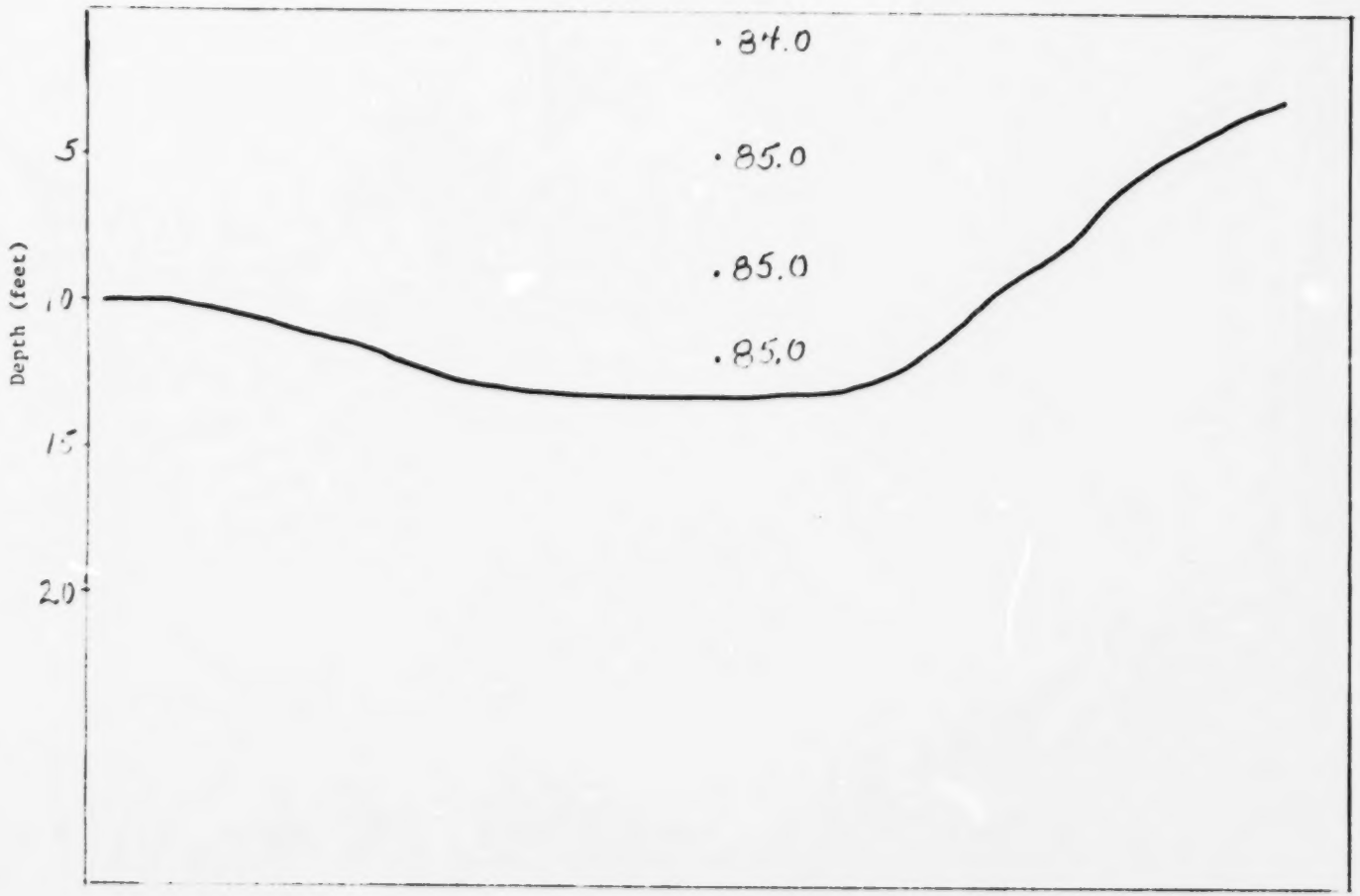
WATER TEMPERATURE (°F) AT STATION 18 ON THE ESCAMBIA RIVER DURING HIGH TIDE - JULY 20, 1972



Cross Section of River
(facing downstream)

Figure 21

VERTICAL PROFILE OF WATER TEMPERATURE (°F) AT STATION 1 (CHANNEL MARKER #20)
ON THE ESCAMBIA RIVER DURING LOW TIDE - JULY 20, 1972



Partial Cross Section of River
(facing downstream)

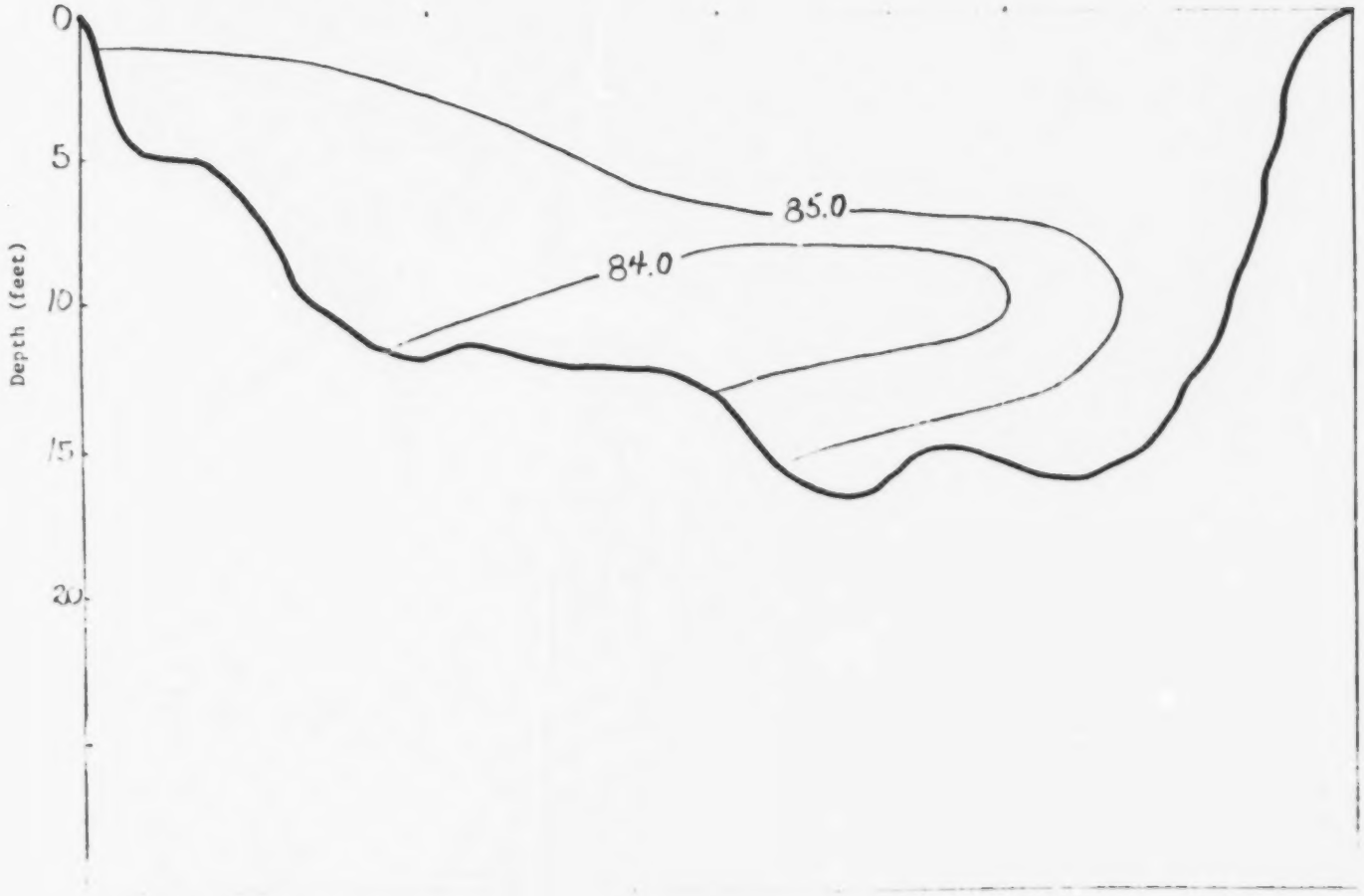
Figure 22

WATER TEMPERATURE (°F) AT STATION 2 ON THE ESCAMBIA RIVER DURING LOW TIDE - JULY 20, 1972

Cross Section of River
(facing downstream)

Figure 23

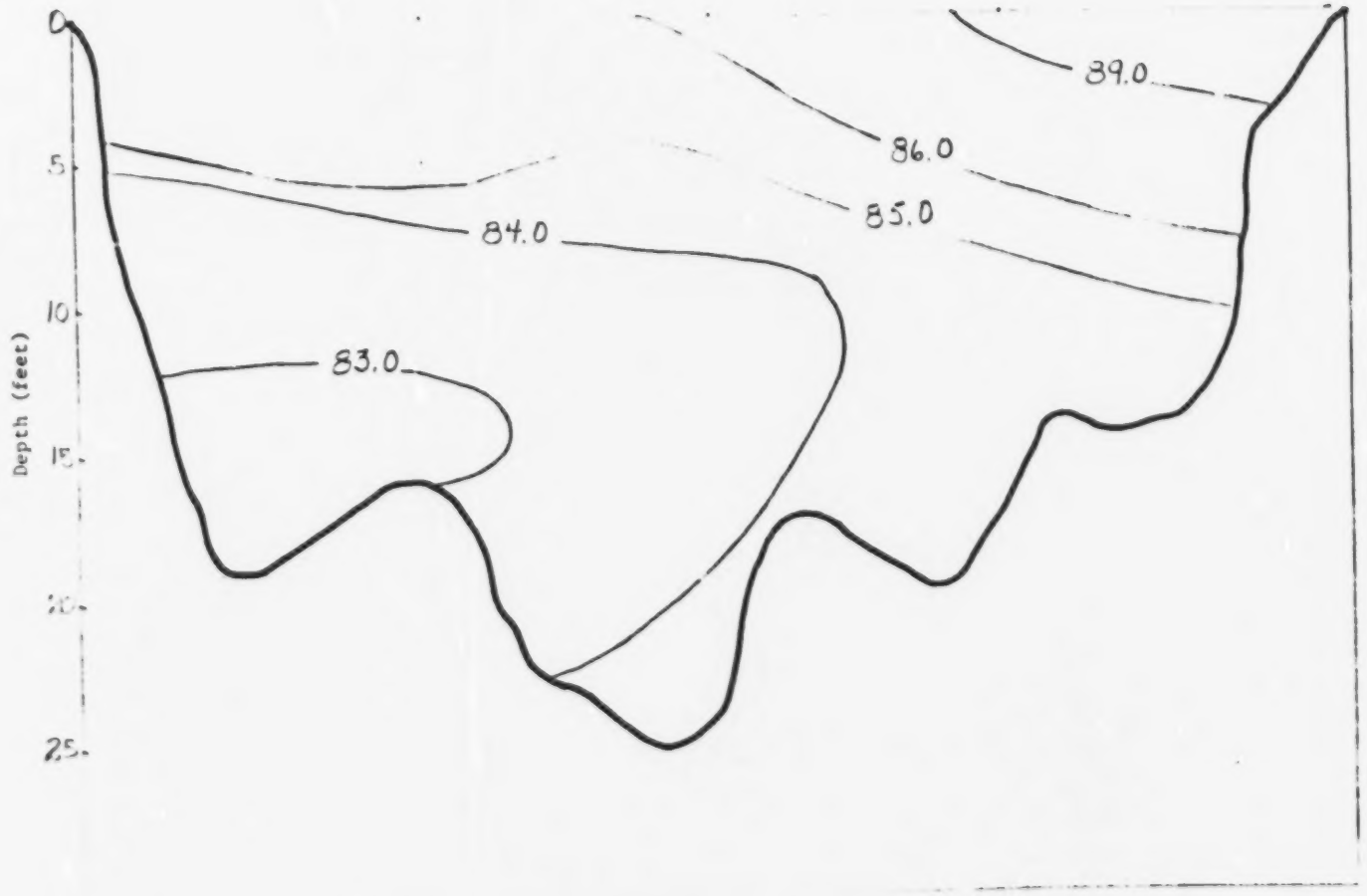
WATER TEMPERATURE (°F) AT STATION 3 ON THE ESCAMBIA RIVER DURING LOW TIDE - JULY 20, 1972



Cross Section of River
(facing downstream)

Figure 24

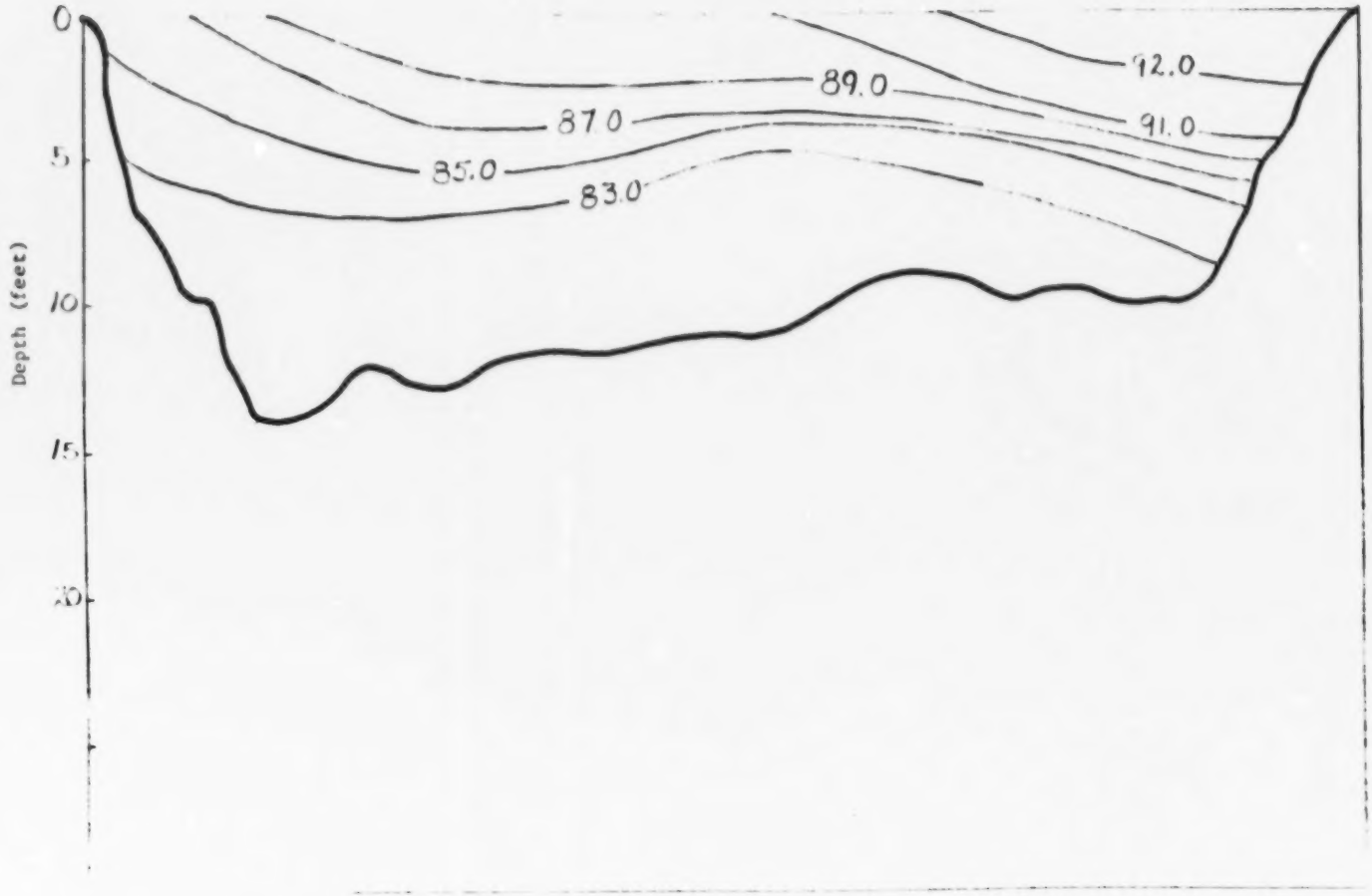
WATER TEMPERATURE (°F) AT STATION 4 ON THE ESCAMBIA RIVER DURING LOW TIDE - JULY 20, 1972



Cross Section of River
(facing downstream)

Figure 25

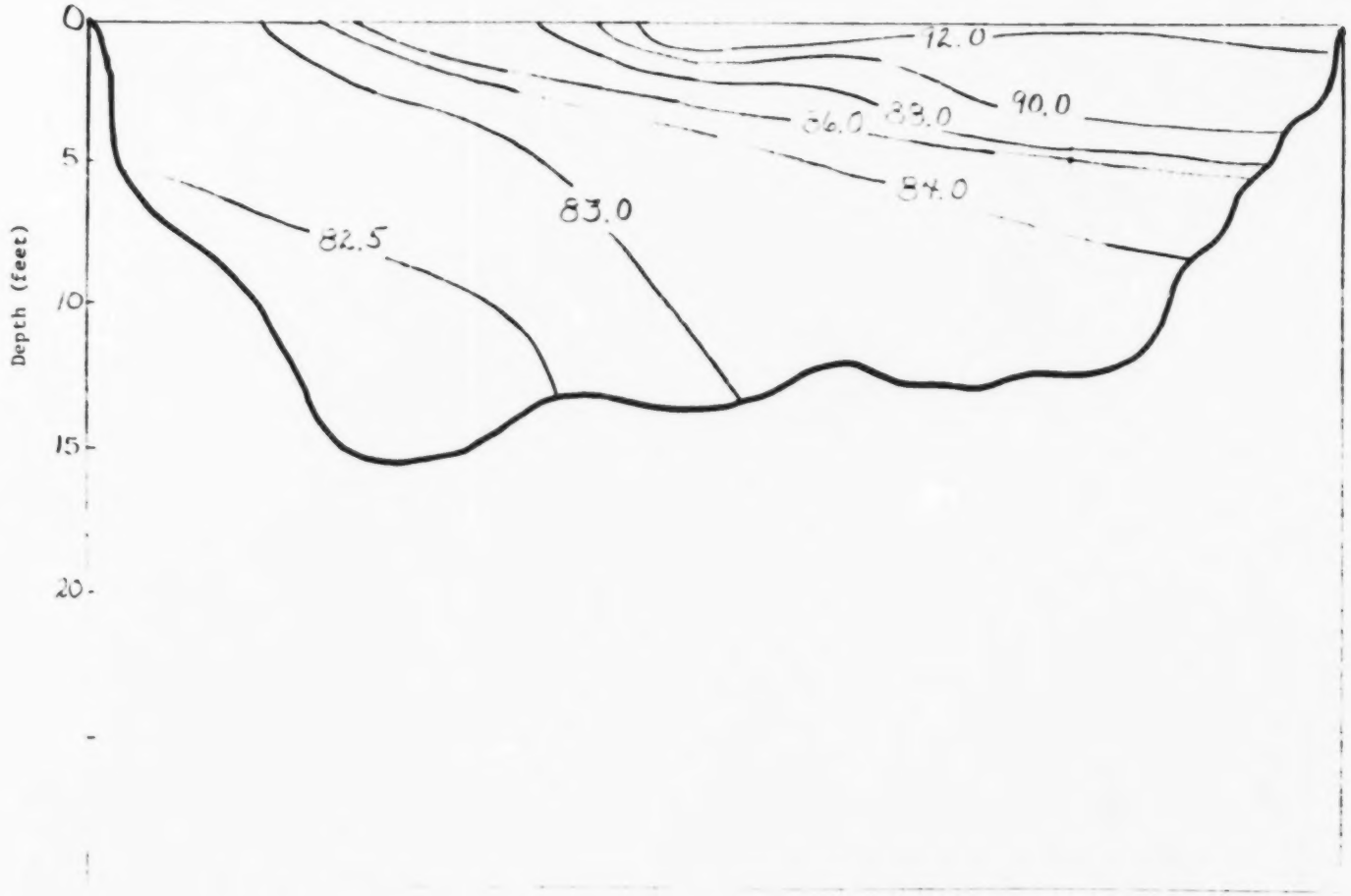
WATER TEMPERATURE (°F) AT STATION 5 ON THE ESCAMBIA RIVER DUPING LOW TIDE - JULY 20, 1972



Cross Section of River
(facing downstream)

Figure 26

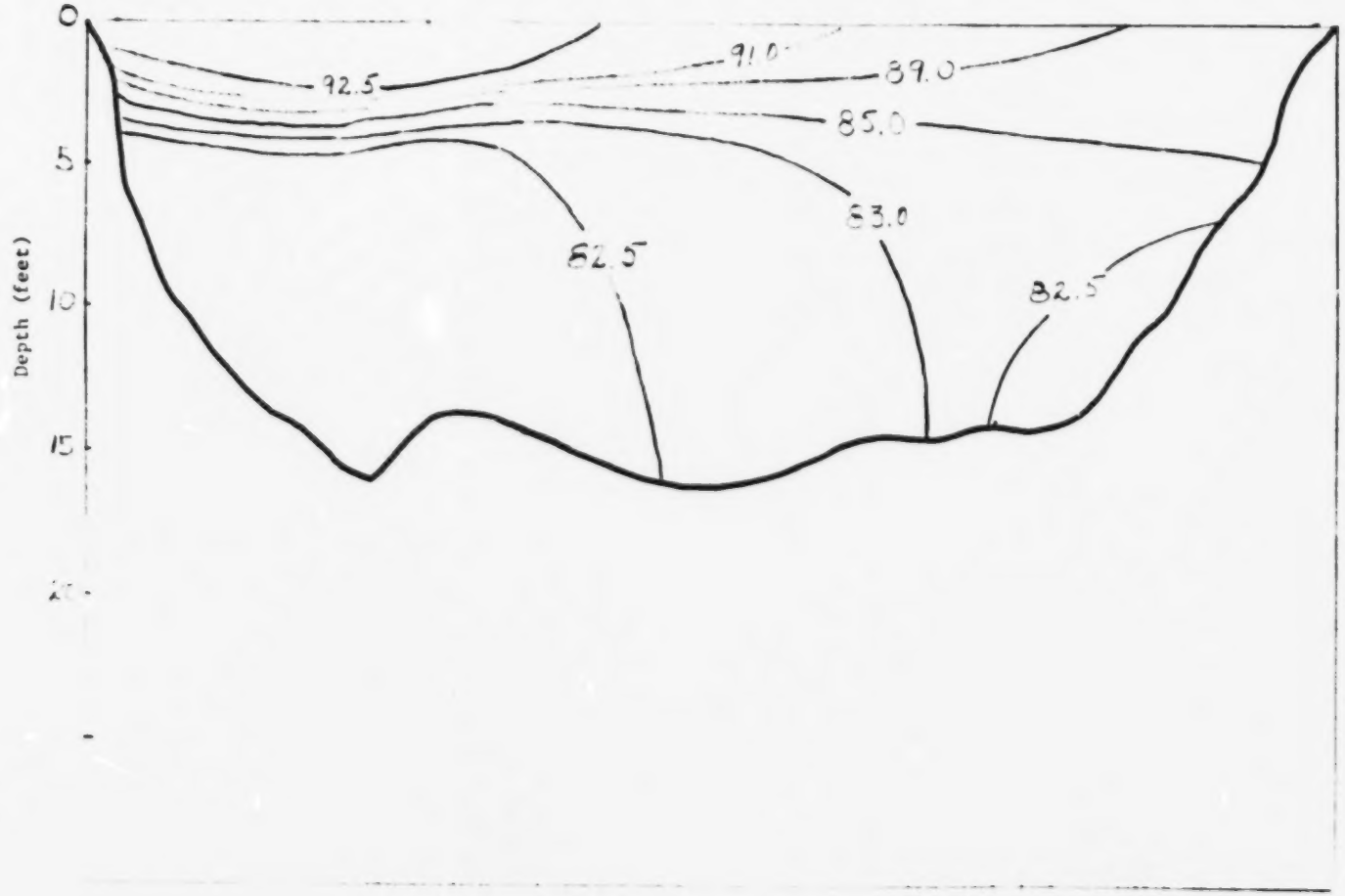
WATER TEMPERATURE (°F) AT STATION 6 ON THE ESCAMBIA RIVER DURING LOW TIDE - JULY 20, 1972



Cross Section of River
(facing downstream)

Figure 27

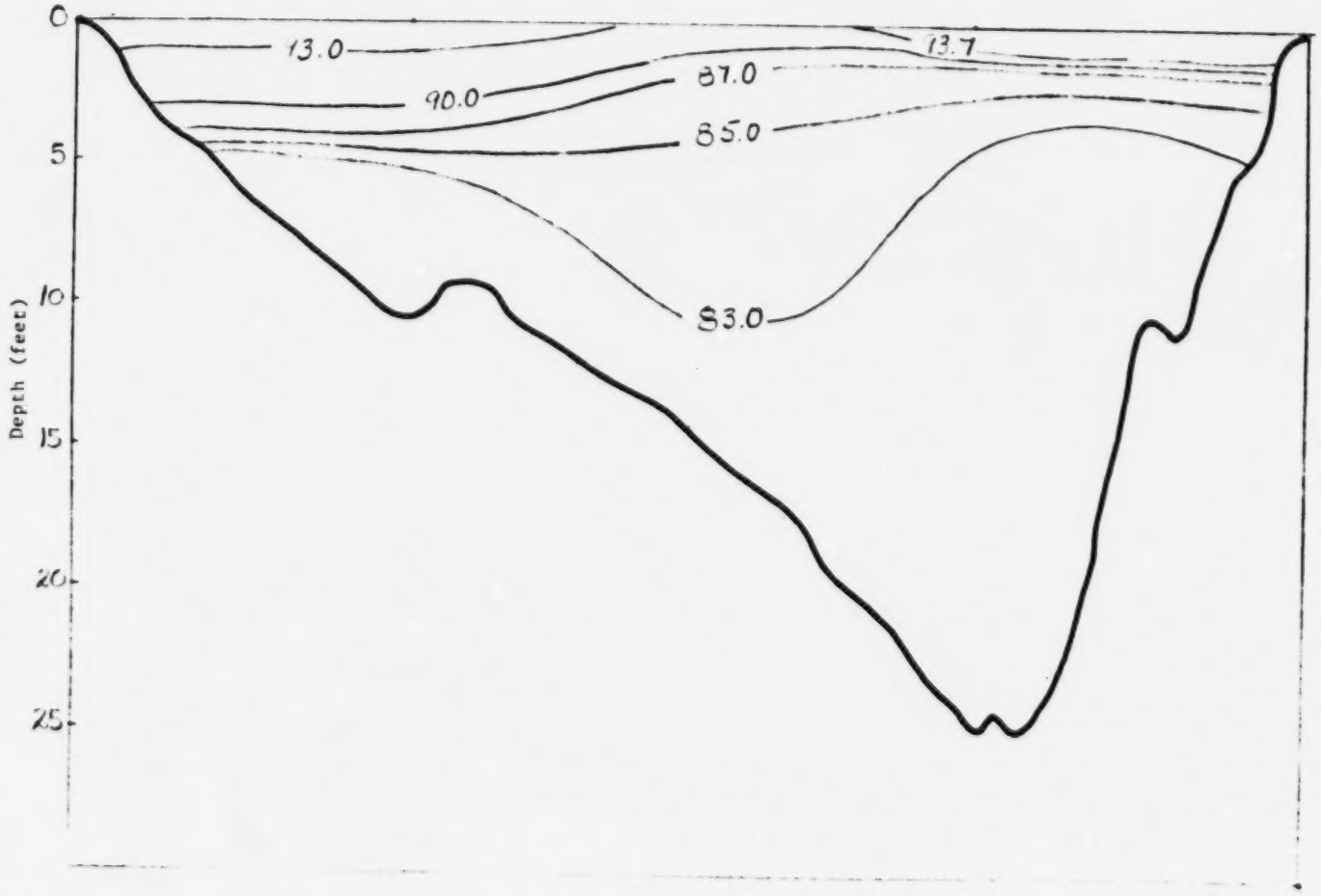
WATER TEMPERATURE (°F) AT STATION 7 ON THE ESCAMBIA RIVER DURING LOW TIDE - JULY 20, 1972



Cross Section of River
(facing downstream)

Figure 28

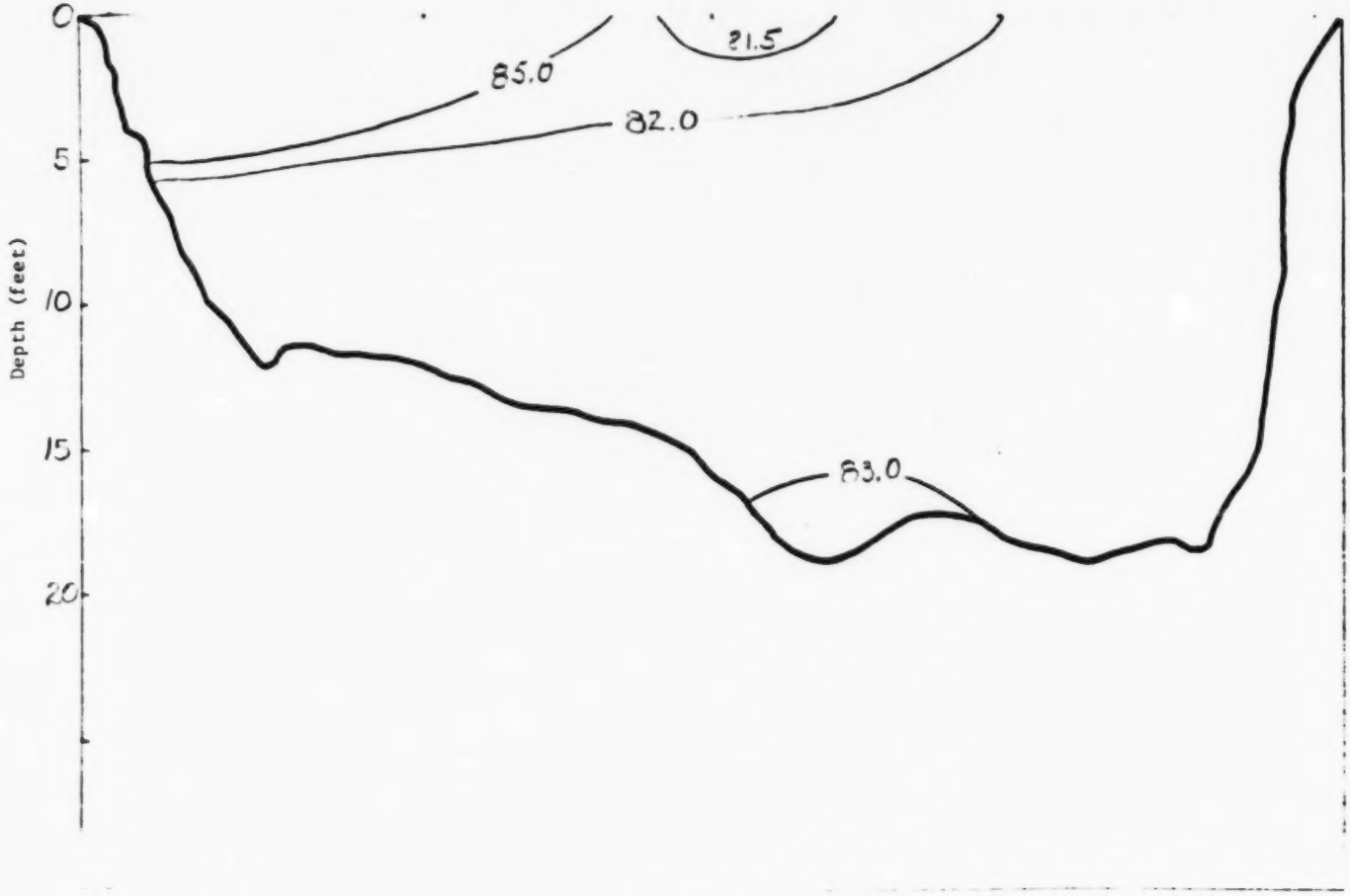
WATER TEMPERATURE (°F) AT STATION 8 ON THE ESCAMBIA RIVER DURING LOW TIDE - JULY 20, 1972



Cross Section of River
(facing downstream)

Figure 29

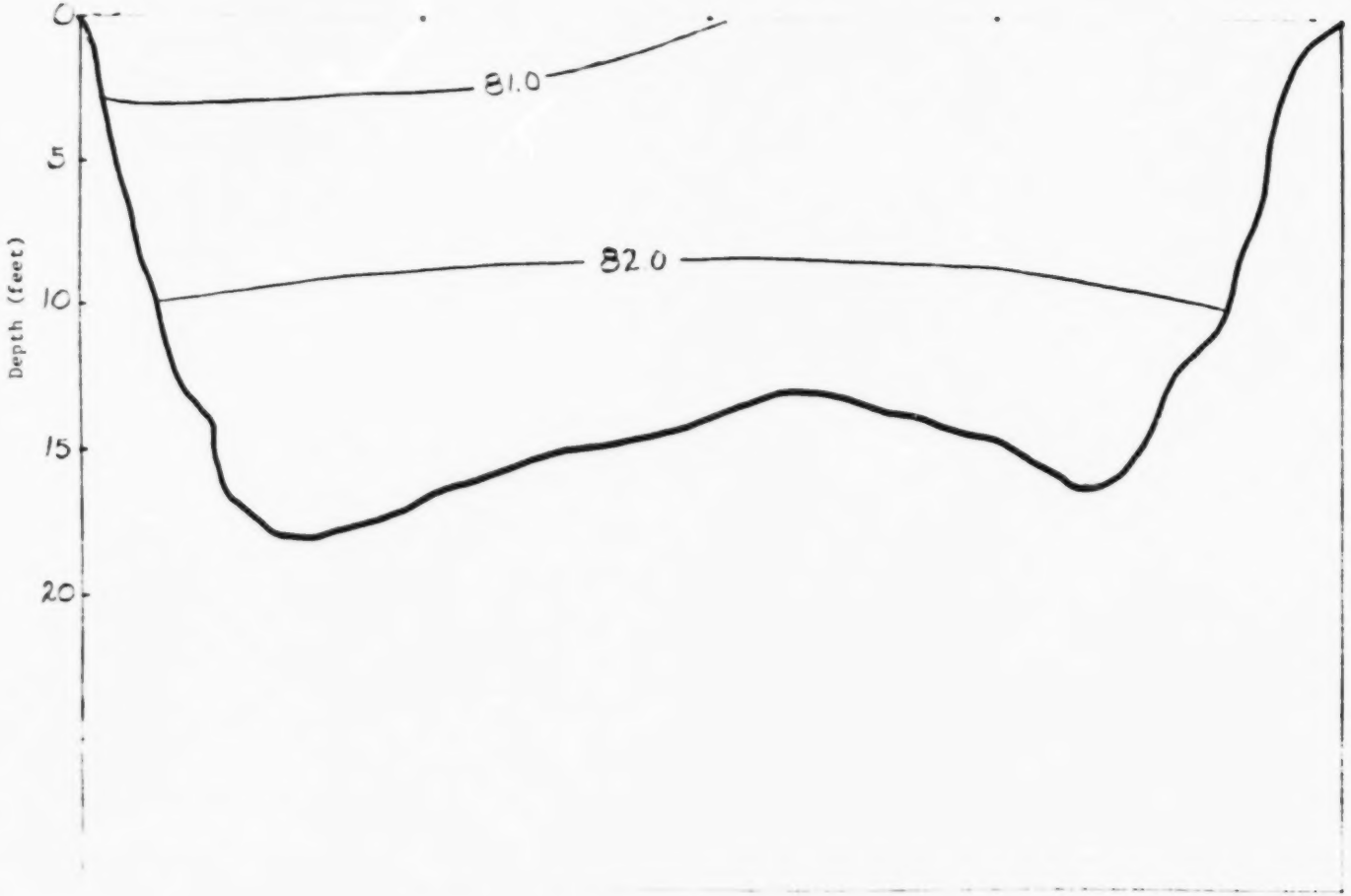
WATER TEMPERATURE (°F) AT STATION 9 ON THE ESCAMBIA RIVER DURING LOW TIDE - JULY 20, 1972



Cross Section of River
(facing downstream)

Figure 30

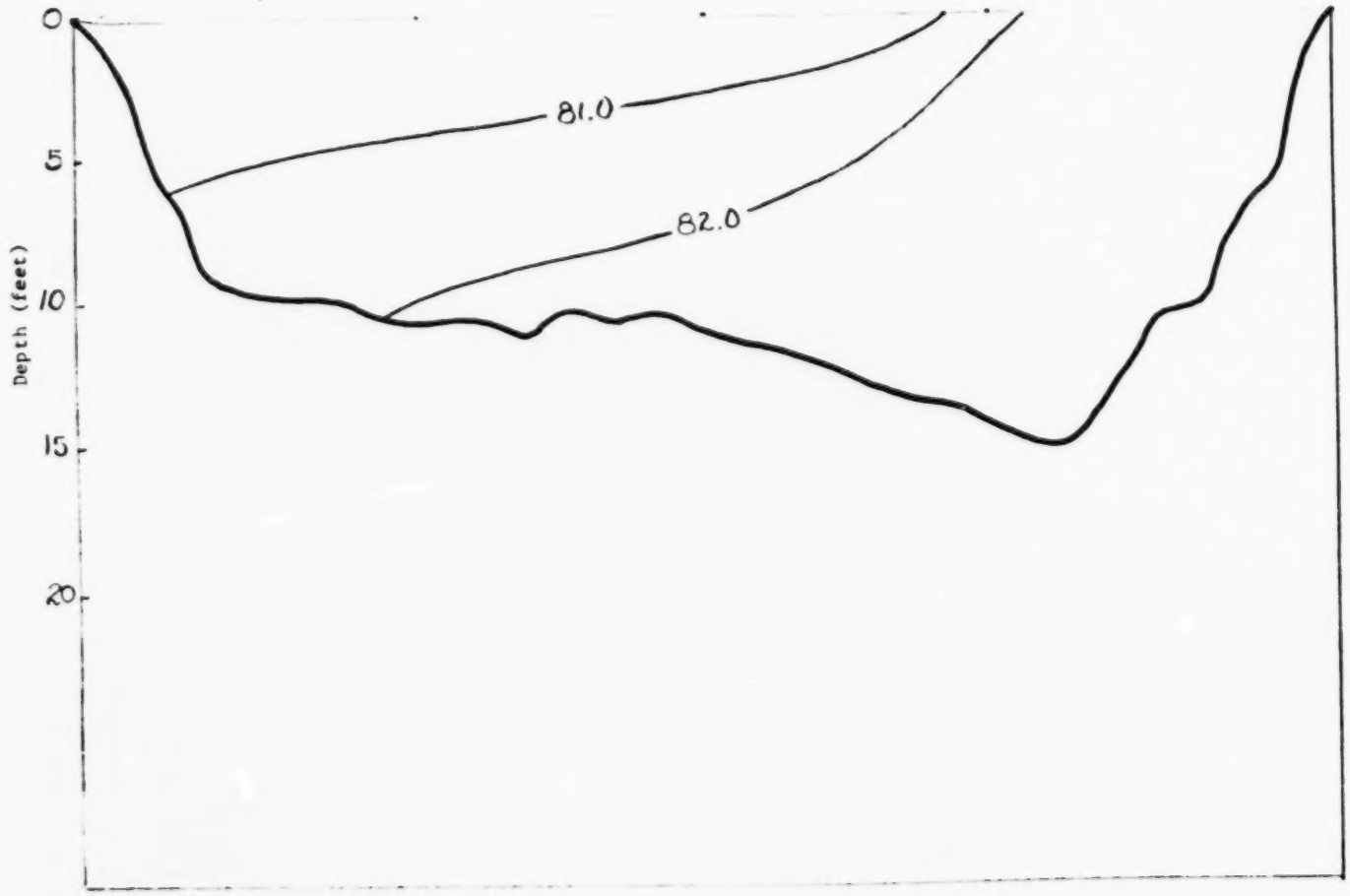
WATER TEMPERATURE (°F) AT STATION 10 ON THE ESCAMBIA RIVER DURING LOW TIDE - JULY 20, 1972



Cross Section of River
(facing downstream)

Figure 31

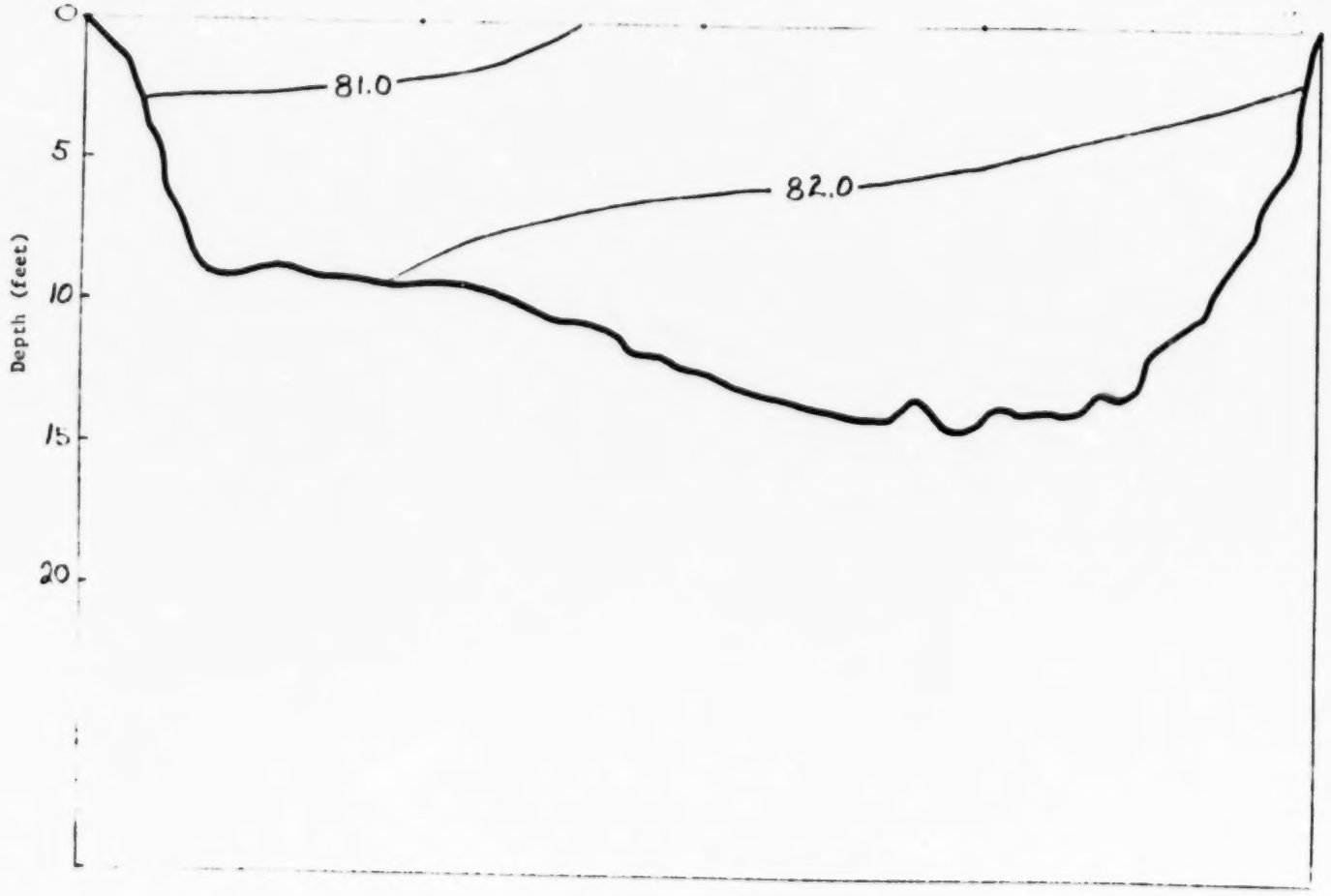
WATER TEMPERATURE (°F) AT STATION 11 ON THE ESCAMBIA RIVER DURING LOW TIDE - JULY 20, 1972



Cross Section of River
(facing downstream)

Figure 32

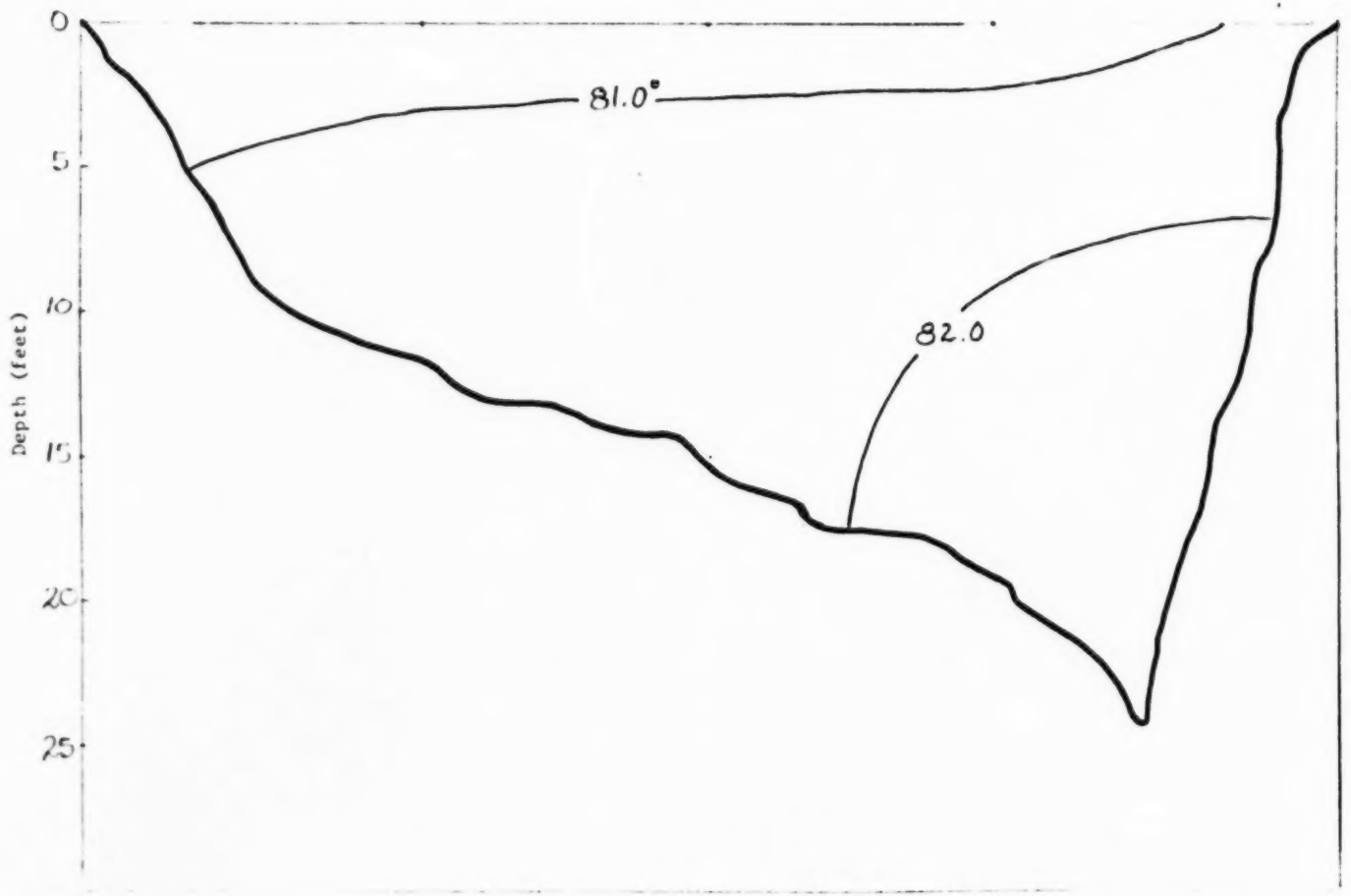
WATER TEMPERATURE (°F) AT STATION 12 ON THE ESCAMBIA RIVER DURING LOW TIDE - JULY 20, 1972



Cross Section of River
(facing downstream)

Figure 33

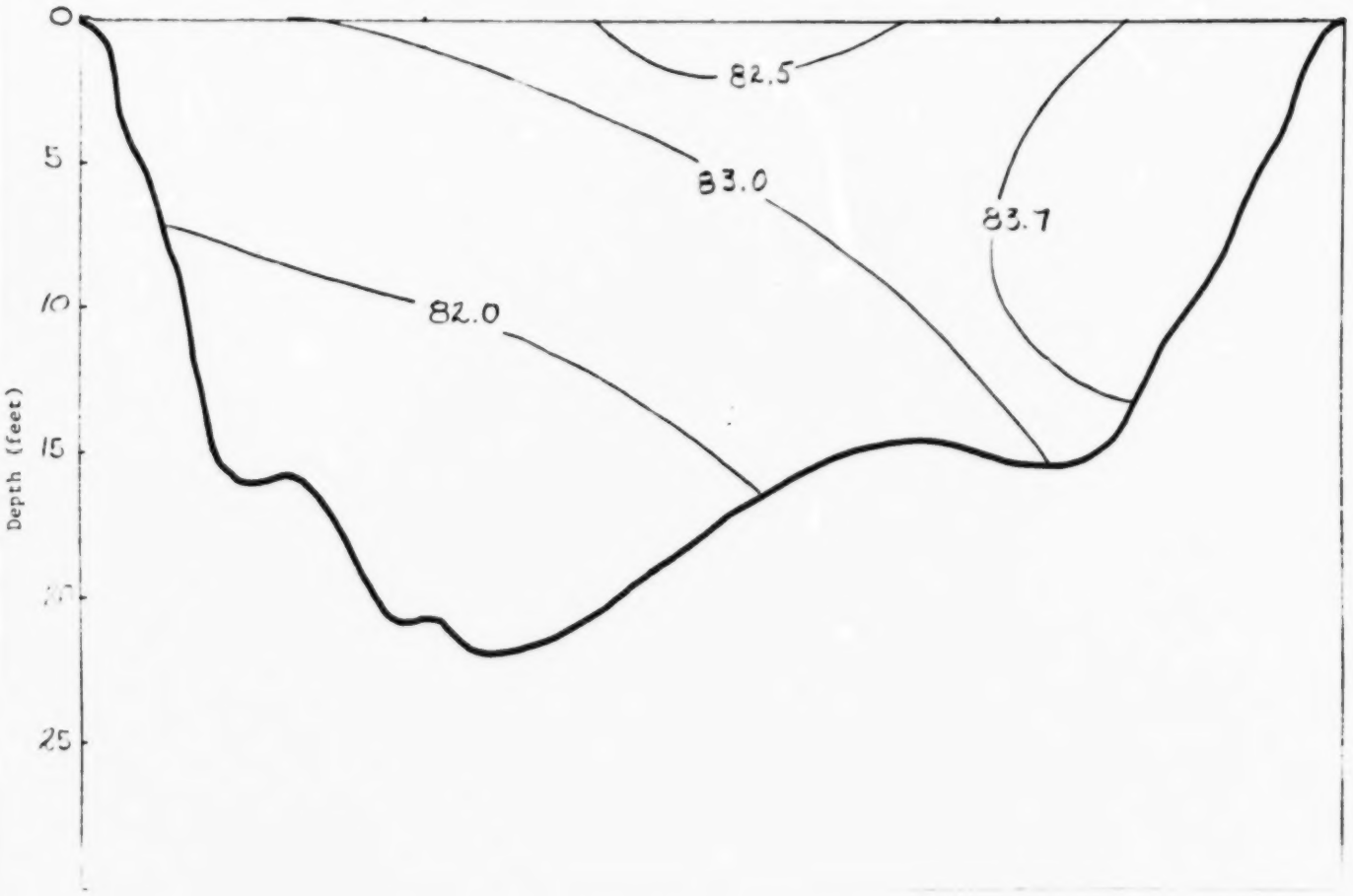
WATER TEMPERATURE (°F) AT STATION 13 ON THE ESCAMBIA RIVER DURING LOW TIDE - JULY 20, 1972



Cross Section of River
(facing downstream)

Figure 34

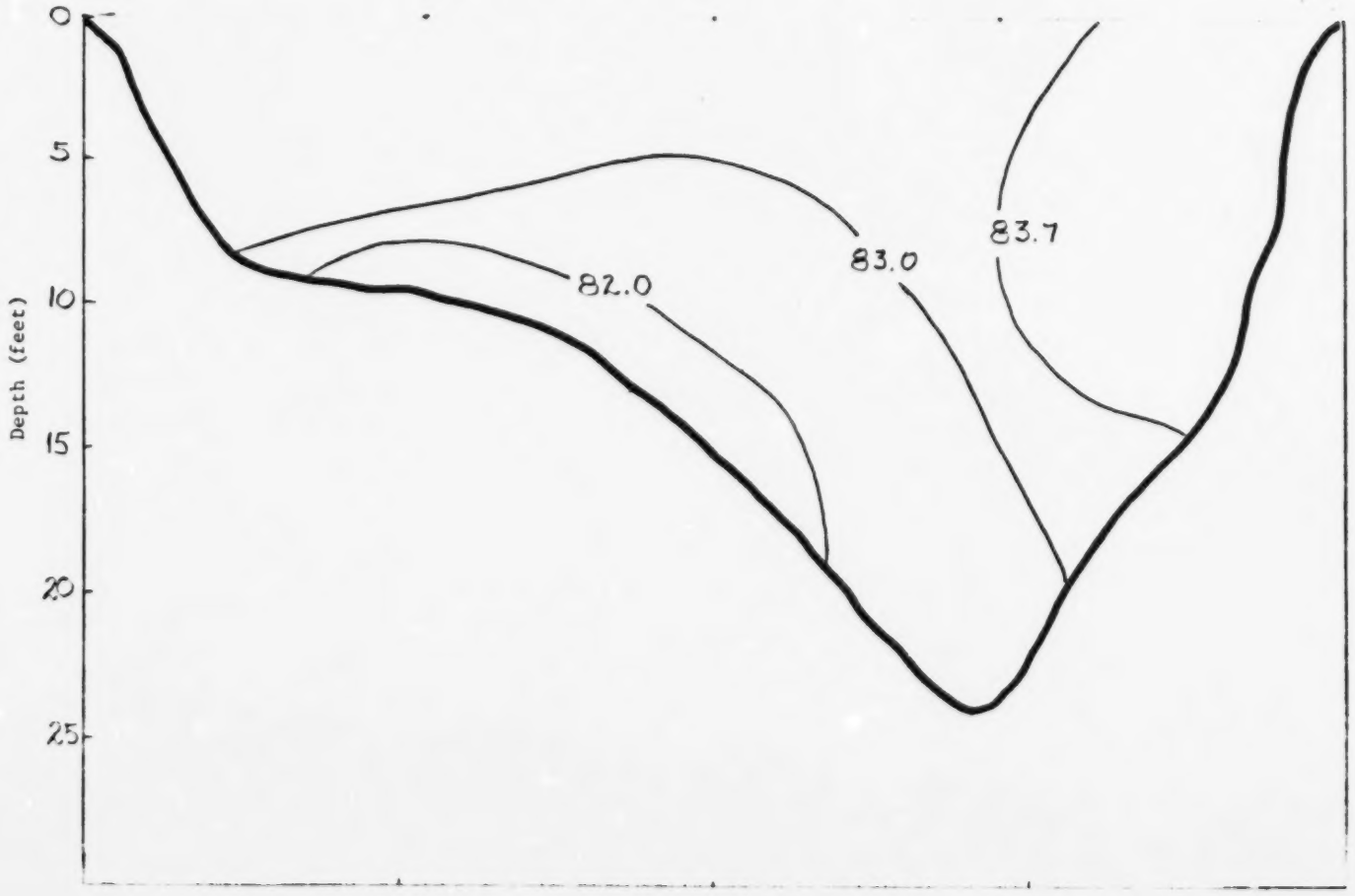
WATER TEMPERATURE (°F) AT STATION 16 ON THE ESCAMBIA RIVER DURING LOW TIDE - JULY 20, 1972



Cross Section of River
(facing downstream)

Figure 35

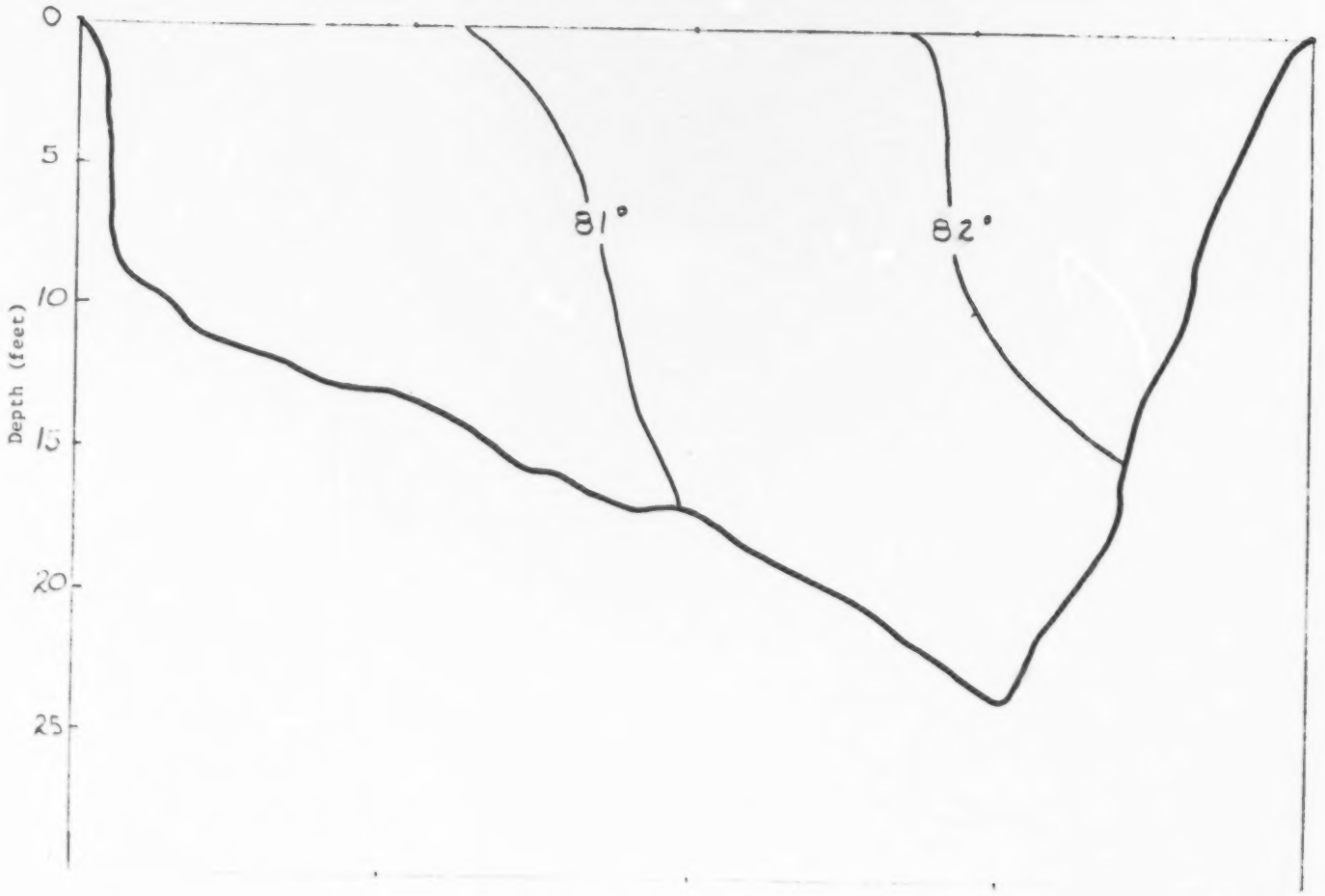
WATER TEMPERATURE (°F) AT STATION 17 ON THE ESCAMBIA RIVER DURING LOW TIDE - JULY 20, 1972



Cross Section of River
(facing downstream)

Figure 36

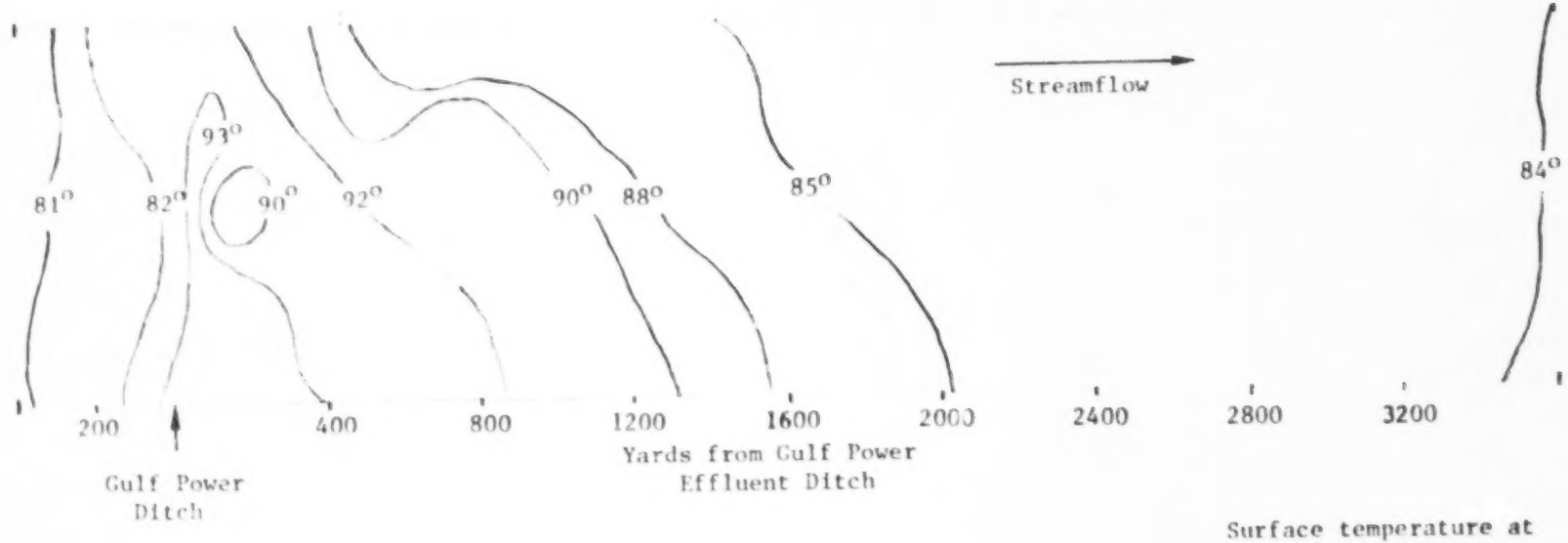
WATER TEMPERATURE (°F) AT STATION 18 ON THE ESCAMBIA RIVER DURING LOW TIDE - JULY 20, 1972



Cross Section of River
(facing downstream)

Figure 37

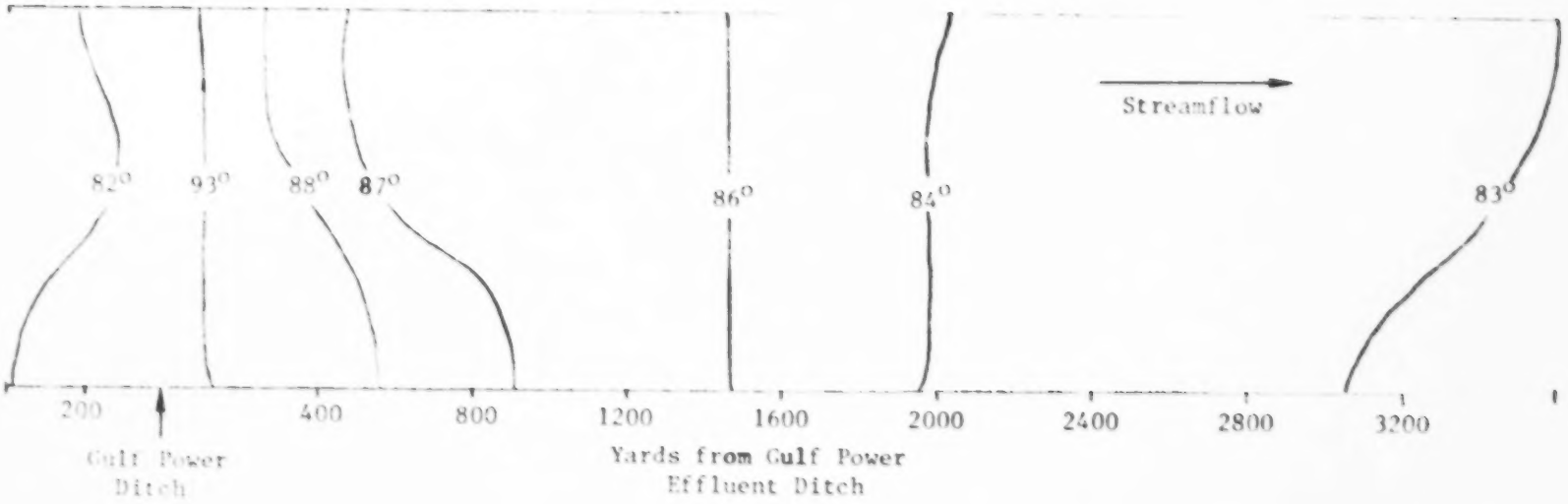
SURFACE TEMPERATURE PROFILE OF THE ESCAMBIA RIVER DURING LOW TIDE - JULY 20, 1972



Surface temperature at Bouy #20 (4400 yards from Gulf Power Ditch) = 84°

Figure 38

SURFACE TEMPERATURE PROFILE OF THE ESCAMBIA RIVER DURING HIGH TIDE - JULY 20, 1972



Surface temperature at Bouy #20 (4400 yards from Gulf Power Ditch) = 83°

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